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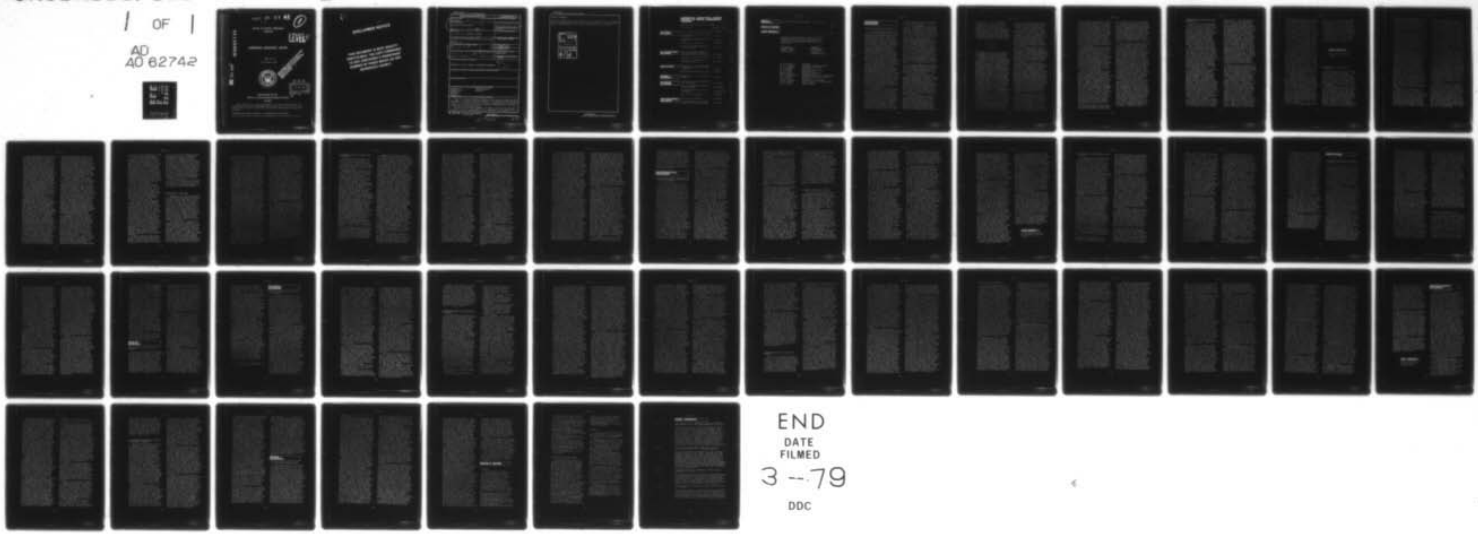

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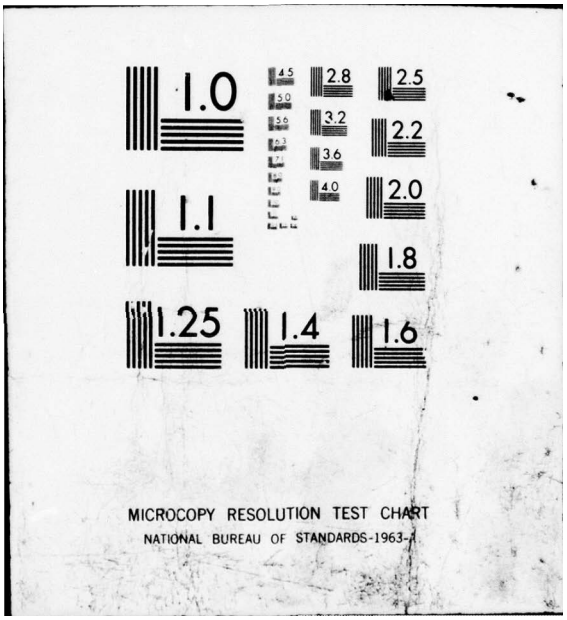
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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.

The articles are written primarily by member of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of the

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Aubrey W. Pryce and Victoria S. Hewitson

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MATERIAL SCIENCES

SURFACE SCIENCE—FAR FROM SUPERFICIAL

The First European Conference on Surface Science was actually the fifth in a series of bi-annual affairs which the Dutch Vacuum Society began in 1970 under the title of the "Solid Vacuum Interface Conferences." The change in name follows the growth of the field and the desire to bring together European physicists, chemists, and technologists working in it under a common banner. The large and enthusiastic conference was held early in June, 1978, at the Royal Tropical Institute in Amsterdam. The generous space and grandiose splendor of the Institute's entrance hall and of its large meeting room came from earlier imperial traditions. For this conference they made possible an easy juxtaposition of lecture hall, social area in the entrance hall, and poster sessions in surrounding galleries, corridors, and board rooms.

To help mix people of various disciplines, parallel sessions were entirely avoided. About 25 papers were given orally, half being invited reviews. The remaining 175 papers were all given in various poster sessions distributed throughout the week of the Conference. This was the most intensive use of poster sessions in my experience, and it seemed to work well. For big conferences, poster sessions are probably here to stay. There was a well-printed book of enlarged abstracts that ran to more than a kilogram and which was genuinely useful. Beyond this it is intended that the proceedings of the Conference will be published as a special issue of *Surface Science* in December 1978.

As contributors to *ESN* have hinted from time immemorial, describing a large conference presents special problems. The approach I shall follow here is to summarize some of the principal papers and then attempt to describe more generally the present status of the field.

In the opening invited paper, M.A. van Hove (Institute for Crystallography and Mineralogy, University of Munich) first reviewed the various techniques available for determining surface structures, then described some of the theoretical progress that has recently been made in analyzing LEED (low energy electron diffraction) data, and finally discussed some new surface structures that are now understood.

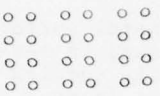
Fast ion channelling in which one looks for blocking by the surface ions may have a resolution of 0.02 Å for the positions of surface ions. At least 6 structures have been analyzed using this technique. Low-energy ion scattering has a resolution of about 0.5 Å and gives easy access to the gross features of surface geometry. Here too, at least 6 structures have been determined. Angular-resolved ultraviolet photoemission spectroscopy tends to be more sensitive to bonding configurations than to exact atomic positions—at least in the present early stage of its development. Van Hove also mentioned XAFS (x-ray absorption fine structure) leading to the emission of Auger electrons from the surface as another new technique. The most important direct methods for surface analysis are still LEED in 2 dimensions, giving information about surface periodicity, and LEED in 3 dimensions that provide atomic positions with 0.05 to 0.20-Å resolution. At least 80 structures have been determined in this way.

Less direct methods used to determine information about surface structures include infrared spectroscopy which provides vibrational frequencies that are related to bonding configurations at the surface. Electron loss spectroscopy is used in much the same way.

The theory of LEED has developed in several directions in response to evolving experimental techniques. Higher electron energies are sometimes used and reflection measurements are common. At other times multiple scattering of electrons must be included. Overlayer structures that are not commensurate with the substrate produced theoretical difficulties but have now been overcome. Since a great deal of computer time may be consumed in a full LEED calculation, simpler and less accurate approaches have been devised to help in preliminary structure searches.

A number of interesting surface structures were mentioned by van Hove. Oxygen adsorbed on a Ni (100) surface sits in a bridge site between two Ni atoms. Sulfur, however, goes into a tetra position nestled between four Ni atoms. When O is deposited on Fe, an Fe atom is pulled above the normal level so as to form a structure that looks like FeO and may be the first step

in oxidation. For the semiconductor world an analysis of the surface of Si could be most helpful. This has turned out to be extremely difficult since there are appreciable lattice distortions down to the fifth surface layer. However the Si (100) surface structure is now believed to be known from LEED. It consists of parallel rows of Si atoms that are well separated from each other, each row having pairs of atoms in it as shown in the figure. If this problem



has finally been solved, it should now be possible to make progress toward understanding the surface structure of semiconductor systems involving GaAs.

A summary of progress in photoemission studies of surface band structures was given by D.E. Eastman (IBM, Yorktown Heights, NY). This is a relatively new technique showing great promise for the future. Although gas discharge sources are sometimes used because of their convenience, the increasing number and versatility of intense synchotron radiation sources tunable from 1-10,000 Å makes them the ideal source. The exciting light penetrates 100 to 1000 Å into the crystal surface and produces photoelectrons which may penetrate through the surface and be detected from as far as 5-20 Å below it. By use of retarding fields, the energy of the electrons can be analyzed, and by use of large area detectors and electron optics the angle of emission can be determined. From these data some properties of the electronic band structure of the surface can be determined. In addition the angle of incidence of the exciting light and its polarization with respect to the crystal directions can be varied to give considerable experimental flexibility.

Some of the problems analyzed with this technique include study of the surface of GaAs. In this case it is found that the surface As atoms move out from the bulk crystal and the Ga atoms move in. The reactions of H and acetylene on Ni have also been investigated. In the case of H, concentrations as small as 1% show a large effect in these experiments. H on Si has also been followed as a function of time. At first a single hydrogen (monohydride phase) is formed on Si, but at larger concentrations a trihydride phase occurs.

The progress of oxidation on Ni, Co, Ti, and Fe was studied by A. Benninghoven, O. Ganschow, and L. Wiedman (Univ. of Münster, FRG). They found it useful to be able to measure SIMS (secondary ion mass spectrometry), AES (Auger electron spectroscopy) and XPS (x-ray photoelectron spectroscopy). In order to use AES without having the measurement disturb the surface, the currents were reduced by a factor of 10^4 and electron counting techniques were employed.

As O is introduced onto Co, for instance, four stages can be followed. There is first a "precursor" stage at low oxygen doses followed by submonolayer O adsorption. Then comes surface oxidation and finally the in-depth growth of the oxidized layer. These steps can also be analyzed after oxidation by removing layers of the surface and determining the character of the oxygen as a function of depth.

Interactions of simple organic compounds with metal surfaces were reported by various groups. J.C. Bertolini and B. Imelik (Institute for Research on Catalysis, Villeurbanne, France) studied the reaction of CO and H on a Ni (111) surface. Using high resolution electron energy loss spectroscopy combined with LEED, thermodesorption, Auger, and work function change measurements, they concluded that a particular orientation of a formate molecule was formed at the surface. J.E. Demuth (IBM, Yorktown Heights, NY) studied the reaction of ethylene (C_2H_4) on a Pt (111) surface using a variety of techniques. He believes that a vinyl species ($CH_2{=}CH\langle$) is formed. This view is supported by evidence that in the reaction one hydrogen atom is removed from the ethylene molecule and bonds to the Pt surface.

As noted earlier the Conference organizers had arranged a number of review lectures that summarized related fields of science. V. Ponec (Univ. of Leiden, the Netherlands) reviewed what is known about the surface composition and catalysis of alloys. Alloys are frequently used as catalysts in the production of high octane gasoline, in selective oxidations, and in desulphurization processes. Ponec divided reactions into two groups. Group I may pro-

ceed on isolated sites and does not depend strongly on the electronic structure of the substrate alloys. In this case alloying simply changes the concentration of the active element. This group includes reactions such as those involving CH, OH, and probably NH. Group II reactions need ensembles of several sites, and the element active for these reactions must be able to form multiple bonds in order to allow the reaction to proceed without the formation of highly endothermic radicals. Dilution effects in this case are related to the size of the ensemble of active metal necessary for a reaction to proceed. Examples of Group II include ether formation from alcohols.

A similar tutorial lecture, on the electronic properties of the insulator-semiconductor interface, was given by F. Koch (Technical University of Munich, Garching, FRG). The problem here is to produce an electrically passive and chemically stable interface so that charge is mobile along the semiconductor surface. This surface layer transport is of fundamental importance in the integrated circuit technology that has produced the microelectronics revolution. The number of charged states at the interface must be less than $10^{13}/cm^2$. In a good $Si-SiO_2$ interface, less than $10^9/cm^2$ has been achieved, i.e., one state per 10^6 surface atoms.

The final talk on technical fields related to surface science was given by M.P. Seah (National Physical Laboratory, Teddington, UK); it was concerned with surface science in metallurgy. He pointed out the broad range of phenomena in metals connected with segregation at surfaces, grain boundaries, and at interphase boundaries. In many cases a simple correlation helps the metallurgist to anticipate the effects. For instance, grain boundary segregation in binary systems correlates inversely with the solubility. In the case of bonding between a metal and an insulator such as Al_2O_3, the highest strength is found for cases with the lowest interfacial free energy. It is evident that many problems in metallurgy connected with embrittlement, fatigue, bonding, and corrosion are connected with changes at a surface and the kinetics in metals that produce the changes.

An observer could not help coming away from this Conference with the impression that although surface science is a field that is being explored with very powerful tools, it yields information with great reluctance. The field has only become widespread with the commercial development of ultra-high vacuum systems. Along with that a wide range of experimental analysis methods have been developed to use on surfaces. However, the experimental results generally need additional theoretical analysis. In the end, imaginative synthesis of a variety of information appears to be essential for interpretation of a "new" structure. Progress has been steady but slow.

Most simple metal surface structures now seem to be known; in semiconductors, silicon is unusually complex but may now be understood. In many cases the position of single atoms, such as O or S, adsorbed on a surface are known. The cutting edge of much of the research seems to be to understand the next more complex processes, and as an example A.M. Bradshaw (Fritz Haber Institute, Berlin, FRG) pointed out that there were 20 papers at the Conference on the subject of CO on surfaces. So, simple adsorbed molecules are a major problem including their position on orientation relative to, and bonding to the surface. In the case of oxygen, the challenge is to follow the atom from its adsorption on the surface through the first succeeding steps as it becomes attached and then moves below the first layer of atoms in the beginnings of oxidation. A detailed analysis of the chemistry and dynamics of the simplest organic molecules, such as C_2H_4, attached to simple surfaces has just begun.

The Conference succeeded in emphasizing the point that there are many important related fields in which surface properties play a central role, such as metallurgy, catalytic chemistry, and semiconductor technology and that these fields have to cope with surfaces even if the details of many processes are not understood at a rigorous atomic level. Surface science and its related application areas are groping toward each other, somewhat as two groups of miners digging an Alpine tunnel from different sides and hoping to meet in the middle. They may still be far apart, but if each group listens carefully it can sometimes faintly hear the rumbles of progress being made by the other. (Clifford C. Klick)

STUDYING DEFECTS IN SOLIDS BY X-RAY DIFFRACTION

The memory of living man barely encompasses the earliest application of x-rays to solids. Since the time when Laue and the Braggs, father and son, sorted it all out, there has been an enormous evolution of apparatus, technique, and theoretical method to reveal the structures of an increasing range of materials now extending to complex organic and biological ones and even to "amorphous" solids. This effort, though, has largely concentrated on the overall structure of material that is normally made as pure and perfectly crystalline as possible.

What I should like to describe is the evolution over about the last six years of techniques and theory that allow one to use x-rays to study the properties of defects in solids with much more detail than had previously been possible. One of the leaders in this development has been H. Peisl, Professor of Experimental Physics at the Ludwig-Maximilian-University in Munich. On a visit with Peisl it became apparent that important progress is being made in applying these techniques both in insulating solids and, more recently, on some basic problems in metals.

Let me attempt to sketch the variety of ways that x-ray scattering can give information on defects. The oldest and best known is the lattice expansion (or contraction) that accompanies the introduction of point defects. The fractional change in lattice parameter ($\Delta a/a$) can be related to the volume of the defect if the concentration of defects is known. Much of Peisl's early work was on color centers in alkali halides where many other techniques such as optical absorption and spin resonance analysis had identified centers, given their atomic compositions, and could be used to measure concentrations. Because of the extensive information already available, these defects and solids were ideal for the development of the new x-ray techniques.

In addition to changing slightly the position of the Bragg diffraction peaks, defects introduce x-ray diffuse scattering on the sides of the peak. It is in the analysis of this scattering that most of the recent advances have been made. Thermal diffuse scattering also is seen in measurements that are made on the wings of the peak. To reduce this complication, x-ray measurements are made at liquid helium temperatures where possible, and then defect scattering can be seen at concentrations of 10^{-4} or even less as compared with the concentrations of 10^{-2} needed for room temperature measurements, which have to be used for the hydrogen in metals problem to be discussed later. The experiment involves measuring the wings of the x-ray diffraction peak with and without defects present. The difference in the measurements represents the diffuse scattering from the point defect. If G is the reciprocal lattice vector of the Bragg peak and g is the deviation from that vector at which a measurement is made, the scattered intensity varies as $1/g^2$. In Peisl's laboratory this scattering is measured with a 6-kW rotating anode x-ray tube, a crystal monochromator to purify the x-ray spectrum, and a scintillation counter and electronics to measure the off-peak scattered intensity. In some published results, counting rates as low as 2/min have been reported.

The scattered x-ray intensity due to defects may not be the same on one side of the Bragg peak as on the other. This asymmetry can be related to whether the defects expand or contract the lattice. In alkali halides, for instance, the asymmetry is found to vary depending on whether interstitials or vacancies are the dominant defect.

Information about the symmetry of the placement of defects in the lattice can also be obtained from this diffuse scattering. A tetragonal defect in a cubic crystal strains the crystal in a different manner than a cubic defect, even when an average over all possible defect orientations is taken. Strain patterns have been worked out theoretically for various combinations of lattice and defect symmetry. In many cases there are lattice directions along which the defect should not introduce strain. Measurements of the diffuse x-ray scattering intensity can then be used to look for characteristic strain patterns, which, in turn, can be related back to the symmetry of the defect in the crystal. Obviously, this information helps to identify the nature of the

defect and its location in the lattice.

An absolute measurement of the scattering intensity can be used to give the total elastic dipole tensor (P) for the defects. The diffuse scattering intensity is proportional to CP^2 where C is the concentration of defects. The lattice parameter change ($\Delta a/a$) is proportional to CP. These two measurements combine in a simple way to allow the defect concentrations to be obtained from x-ray measurements alone. If point defects aggregate into clusters, two effects are seen. The diffuse scattering for small values of g continues to vary as $1/g^2$, but the total scattered intensity increases by a factor which is equal to the average number of atoms in a cluster. At larger values of g the scattering intensity may break off into a $1/g^4$ dependence, and the value of g at which the break occurs can be related to the size of the cluster.

In the last few years Peisl and his group have turned their attention from alkali halides to study hydrogen in niobium and tantalum. This problem has attractions for its own sake: Hydrogen is one of the simplest forms of defect in metals, therefore it offers a fundamental challenge. In addition, however, hydrogen in various metals plays a very practical role. It is doubtless a principal actor in a process of major concern to naval materials people and designers—stress corrosion cracking in steel. Also, if a hydrogen fuel energy economy should develop, the behavior of hydrogen in metals would become of even greater importance.

In order to prevent isolated interstitial hydrogen atoms from condensing into a "liquid" phase in metals, x-ray measurements must be made at ordinary rather than at liquid He temperatures. Thermal diffuse x-ray scattering is then large and the concentration of hydrogen must be increased correspondingly. At room temperature, concentrations up to 2.7 at. % can be used in Nb and up to 11.1 at. % in Ta. The results in Nb and Ta are similar and surprising. It seems clear from much other work that hydrogen occupies a tetragonal site in the metal. However, the x-ray measurements show that the displacement field transmitted to the lattice has cubic symmetry. How this comes about is apparently a mystery.

Peisl and his group are busy installing a new 60-kW rotating anode x-ray machine. This will allow them to make scattering measurements further off the Bragg peak and give information about the displacement of atoms closer to the defects. Members of the group are also beginning to do scattering experiments on defects using neutrons.

While a great deal of information appears to be available from the wings of the Bragg x-ray peaks, Peisl points out that there must be still more information in the very low-level scattering between the peaks. Obtaining this information experimentally and analyzing it is a challenge for the future. (Clifford C. Klick)

ONRL REPORTS

See the back of this issue for abstracts of current reports.

SPLAT!—RAPIDLY QUENCHED METALS CONFERENCE

The Third International Conference on Rapidly Quenched Metals, held 3-7 July 1978 at the University of Sussex, Brighton, UK, was sponsored and organized jointly by the Materials Science Group of the University and The Metals Society. The program, put together by Prof. R.W. Cahn and his committee, comprised more than 125 papers from 18 different countries, and there were about 235 attendees.

The term "rapidly quenched" (RQ) has been lately adopted to describe the process of cooling a metal at a very high rate from the liquid phase, while the more descriptive original term, "splat cooling," has been pretty much discarded ("splat" is also the sound you make if you fall off the nearby White Cliffs of the south England coast). RQ metals are usually, but not always, "metallic glasses" (amorphous metals) since the RQ metal may not be totally rendered into the glassy state, or may not remain glassy, particularly as time and tempera-

ture increase. When RQ metals are not amorphous, they are generally microcrystalline in form, i.e., have very fine microstructural features that are also of interest. An amorphous state can also be produced by means other than rapid quenching of the liquid, such as by vapor quenching, or by ion beam bombardment or laser glazing of a solid surface.

Metallic glass alloy compositions typically are composed of either one or more transition metals (Fe, Ni) or a noble metal (Pd, Au) and one or more metalloid elements (P, B, Si). The classical (most-studied-to-date) base compositions are Fe_4B and Pd_4Si. Currently, the common form of metallic glass product is thin strip (typically less than 100 μm in thickness), with one of the key problems being to produce larger-area, thicker, and higher-quality sheet material.

Metallic glasses are of special interest for many reasons. From a practical viewpoint, amorphous metals are variously found to have high strength, corrosion resistance, resistance to radiation damage, zero or negative coefficient of electrical resistivity, low ultrasonic attenuation, magnetic softness (low coercivity and magnetostriction), and other unusual properties. The study of RQ materials has attracted the interest of scientists in many basic disciplines, including metallurgists, solid state physicists, chemists, crystallographers, surface scientists, experts in heat transfer and fluid dynamics, and also of engineers and technologists in various specialities. Study is providing insight into a number of fundamental problems such as phase stability, crystallization kinetics, diffusion, structural defects, etc. These wide-ranging interests were reflected at Sussex by the large number of countries active in research and the range of scientific disciplines involved.

Judging by the contributions to the Sussex conference, one might conclude that most work in the field is centered on the basic physical questions, with much less attention to technological application. The program was divided into seven topic areas: Techniques of Rapid Quenching, Metastable Crystalline Alloys, Formation and Stability of Metallic Glasses, Physical Properties of Rapidly Quenched Alloys, Magnetic Properties of Glasses, Application of Rapidly Quenched Metals, and Structure and Flow of Metallic Glasses. These are essentially the same areas assigned at the last conference, in 1975, with the addition of a separate session on applications. Unfortunately, the applications session did not live up to its billing, which is certainly due at least partly to the fact that it is currently not clear what the primary applications for RQ metals will be. Moreover, the very interesting subject of applications was not particularly well reviewed in any single paper, which may have been because of a desire on the part of the organizers to have a basic science emphasis in the contributions. Collectively, however, contributions reflected a wide range of special applications, some examples of which will be briefly mentioned here.

In the area of techniques, H.A. Davies (Univ. of Sheffield, UK) reviewed some of the technologically promising schemes to produce metallic glasses, including melt-spinning (jetting onto a rotating piece), melt extraction (touching a rotating piece to a static pool of molten metal), melt extrusion, twin-rolling of a jet, etc. Other papers in the session on techniques dealt with the fundamental nature of the actual phenomenon of rapid liquid quenching. For example, such features as splat puddle geometry, which relates to important operational variables such as spin velocity, and the effect of inert gas and vacuum environments were considered. These studies included excellent photographic and cinematographic evidence, by H. Hillman and H.R. Hilzinger (Vacuumschmelze GmbH, Hanau, West Germany) and J.L. Walter and H.H. Liebermann (General Electric Research Lab, Schenectady, N.Y.), respectively.

A particularly exciting paper, contributed by R. Clampitt *et al* (UKAEA, Culham Laboratory, Abington, Oxon, UK) dealt with electric field atomization from the melt, a possible method for producing glassy surface coatings, similar to vacuum deposition techniques. In this scheme an electric field is applied to the melt surface to create the well-known Taylor cone phenomena; these fine peaked features break into high-velocity streams of ionized particles, which may then impinge on and coat a target surface. The droplets are typically micron-size but can be as small as single atomic ions, so that the technique in the limit approaches ion implantation.

A review paper by N.J. Grant (MIT, Cambridge, MA) on applications of crystalline RQ materials was a singular departure from other presentations at the conference in that it emphasized the practical state-of-the-art. A similar "plain-talk" presentation would have been useful in the area of glassy alloys. Grant reported on the considerable interest in the properties of consolidated RQ powders of superalloys and high-speed tool steels produced by gas atomization. Generally speaking, those materials tend to have higher strength, lower ductility, lower high-temperature creep resistance, and better hot workability than conventional cast superalloys. Also, alloy compositions can be varied beyond the usual range to impart improvements not obtainable in conventional alloys, such as better low-cycle fatigue behavior or enhanced oxidation resistance. Currently, some of the key problems are to reduce the complexity and cost of both the RQ powder production and consolidation procedures, and the scatter in mechanical properties' data due to gas pores and oxide inclusions.

Davies also gave attention to theoretical aspects of metallic glass formation, and tried to identify the important factors that affect the glass-forming tendency in metallic systems, such as the alloy melting temperature (T_m), glass transition temperature (T_g), and properties of the melt such as viscosity. He suggested that a useful index such as the ratio T_g/T_m could be used to predict glass forming ability, with higher values indicating easier glass formation, i.e., its possibility at lower cooling rates. The glass forming ability and the stability of the glass phase have important technological implications in determining the maximum glassy section thickness that can be produced and the maximum service temperature, respectively. It would be of great value to be able to predict these behaviors accurately for new alloys, and although the T_g/T_m index may be an oversimplification from a fundamental viewpoint, it seems to have definite usefulness. There were few attempts at this Conference to generalize or to formulate principles from the diverse data, yet efforts in this regard seem to have special merit, especially to observers outside the mainstream who are trying to sort out the essence of the field. B.C. Giessen (Northeastern Univ., Poston, MA) and co-workers contributed a paper that also attempted to delineate criteria for glass formation. This paper was couched more in terms of classical alloy phase theory, and the significance of such parameters as atomic size ratio, e/a ratio, and melting point depression were discussed. In my opinion, this effort to consolidate ideas regarding glass formation and stability was one of the most innovative contributions to the meeting, an especially refreshing experience after long series of talks each dealing with a particular narrow range of data.

Magnetic properties of amorphous alloys were reviewed by C.D. Graham, Jr. (Univ. of Pennsylvania, Philadelphia, PA). Currently, one of the few commercially developed materials is in this applications area, i.e., the use of Fe_4B type alloys as magnetic shielding material; Allied Chemical Company currently produces a commerical product which consists of a basket weave of glass alloy strips (about 2 mm wide). Graham pointed out that glassy alloys sometimes approach the "ideal" soft magnetic material: They can be strongly magnetic, with thick domain walls and low anisotropy energy; they are homogeneous, have high electrical resistivity and low eddy current damping; and they are low in magnetostriction. Possible applications, in addition to magnetic shielding, include tape recorder heads and Permalloy-type applications in power transformer devices. Problems in developing these applications include processing difficulties, low saturization magnetization values, and stability of the glassy state.

The behavior of amorphous superconducting compositions such as $Nb_3(Al, Si)$ and $Nb_3(Al, Ge)$ was discussed by several authors. One of the important features is that the electron mean free path (mfp) is very small, on the order of atom distances; the electron mfp is related to the coherence length and so to the penetration depth; coherence length is on the order of 500-1000 Å for a crystalline material, but only about 10 Å for the corresponding amorphous material. Thus the inversely related penetration depth is much larger for the amorphous state, as is the upper critical field, Hc_2, while the lower critical field, Hc_1, is smaller. Another aspect of amorphous superconductors is that because the structure cannot be further disordered, the materials are effectively resistant to radiation damage

and so may be useful in nuclear (including fusion) reactor applications.

It was obvious from the number of contributions that an area of major interest and importance is the crystallization of metallic glasses. This subject was ably reviewed by M.G. Scott (Univ. of Sussex) who pointed out that there are both scientific and technological reasons for study of metallic glass crystallization. Scientifically, the phenomena offers an opportunity to study crystal growth in highly undercooled media, whereas from a practical standpoint, the stability of the glassy state is often essential. Additionally, crystallization from the glassy state, by purposely annealing, may offer routes to new and otherwise unobtainable microstructures. This opens a whole new arena for alloy designers.

On the basis of their mechanical properties, amorphous metals tend to be stronger and less ductile; they are also usually very poor in the crystalline state, owing to their high nonmetallic content. Direct load-bearing applications for metallic glasses were not considered at the Conference, although some references were made to their possible use as reinforcement materials in other matrices.

Chemically and electrochemically, the major feature that distinguishes amorphous metals from normal alloys is their compositional and microstructural homogeneity. There are no grain boundaries, precipitates, etc., to be attacked preferentially, which rules out certain corrosion modes. Several contributions were made by workers from Tohoku University, Japan, on the corrosion behavior of metallic glasses, and although some interesting data are being developed, as yet there are no established principles regarding the electrochemical behavior of amorphous alloys. It would be of great interest to develop further electrochemical data on such materials and to delineate their relative activities, polarization behavior, etc. Since the behavior of amorphous alloys is quite different from the corresponding crystalline material, this is an area that should be quite revealing as it receives more attention.

In spite of the fact that this was the third international conference on RQ metals, this is still a very young field. As would be expected for an emerging area of science and technology, it is in the process of defining itself, particularly in terms of the primary directions that research will take. Although the scientific content of the subject is definable in fairly familiar terms of metal physics, the field as a whole seems to be in a state of ebb and flow, i.e., it does not have a consistent momentum in any single direction. In this sense, it is a very exciting field, one which may at first sight seem to be a specialized niche of metallurgy, but which is actually a treasure trove of insight for many scientific disciplines. We would seem to be guaranteed numerous scientific and technological revelations as a result of continuing research in this area.

A more complete account of this Conference will be available in a forthcoming ONRL Report. The proceedings of the Conference will eventually be published as a separate volume. (Jeff Perkins)

RUSTING AWAY?: DIAL-A-FIX

Suppose you run a chain of laundries in Cleveland and all your hot-water boilers have become corroded and are springing leaks. Where would you get advice on how to stem the tide? You would have to do the same thing you would do if you had a toothache—seek private advice. There is no dole for technical assistance in the US. However, if your laundries are in Brighton, Watford, or Kings Cross, you can get free corrosion advice from your friendly government corrosion man just by picking up the phone. If your problem is relatively simple and he can provide a solution without too much time spent, there will be no charge. If he can't help, he will refer you to a specialist.

This "rusty" piece of British socialized bureaucracy is embodied in the National Corrosion Service (NCS), an advisory and consultative service operated by the Department of Industry (DOI) to give advice to UK industry on corrosion problems. It has broad scope, and can provide a wide range of services in many sectors of industry. In addition, through close cooperation with other organizations which have specialist knowledge of corrosion, NCS can provide referral to additional sources of information and assistance when appropriate. Physically, NCS is located at the National Physical

Laboratory (NPL), Teddington, Middlesex TW11 0LW (Telephone: 01-977-3222). The Head of the Service, Dr. Peter Rothwell, explained the origins and workings of NCS to me during a recent visit.

The NCS was established by the DOI on the advice of a prestigious Committee on Corrosion (see Herman *ESN* 30-2:64), to provide guidance to British industry on problems of corrosion and to assist in the application of corrosion control measures, especially in cases where the industrial concern cannot maintain its own full-time corrosion technology. The impetus for establishment of the Service was the publication, in 1971, of the famous Report of the Committee on Corrosion and Protection (known as the Hoar Committee, for Prof. T.P. Hoar of Cambridge, chairman). This report estimated the losses due to corrosion in the UK to be over £1,300,000,000 per annum, approximately 3.5% of the GNP at that time. Further, it was estimated that some £300,000,000 per annum could be saved through increased awareness of the problems and application of existing knowledge. It was considered essential that improved communication be provided between industries having corrosion problems and corrosion technologists who often already have proven methods of corrosion control.

NCS offers such services as information, data, advisory service, troubleshooting, failure analysis, literature searches, materials selection, design exercises, etc. The staff consists of Rothwell, three other corrosion engineers and a secretary. Straightforward information and advice not involving undue expenditure of staff time are provided gratis. More extensive projects are charged on the basis of staff involvement plus the cost of chargeable facilities used. NCS will assist in defining longer in-house corrosion programs for clients and will monitor such programs if required. All services are available on an ad hoc basis, but NCS will enter longer term consulting agreements as well.

Beyond its own small staff, NCS is linked into a wide-ranging network of corrosion advisory services that have been set up with DOI encouragement. For example, NCS belongs to a loose consortium of about 14 advisory centers in Britain listed by the DOI's Committee on Corrosion. These centers include university, industrial, and government advisory services, and meet perhaps once a year to exchange information on services and facilities available so that easy referrals between them are possible. DOI also publishes a comprehensive Corrosion Prevention Directory (available from Her Majesty's Stationery Office, London, at £3.25) that lists advisory services, consultants, suppliers of corrosion control materials, standards, professional societies, corrosion periodicals, books and texts, sources of education and research, and even a glossary of corrosion terms.

Rothwell indicated that the current inquiry rate is about 800 per year, or about 3 per working day, and is steadily increasing, an indication of the Service's success. In the 3 years of its existence, NCS has provided service to a wide range of clients, including oil and chemical industries, shipping, food and drink manufacturers, marine engineering, water supply and treatment, etc. Many specific gains made by these interactions can be cited, consistent with the DOI's original goals for the Service. These goals include the desire to help avoid premature repair and replacement of industrial equipment, to minimize unscheduled plant shutdowns, to reduce waste and contamination due to corrosion, and to increase efficiency and safety.

There would seem to be no US parallel to this activity. Although some of NCS activities overlap those of the National Association of Corrosion Engineers (NACE), the purview of NACE is basically different. Indeed, the UK has its own corrosion science professional and engineering societies, such as the Institution of Corrosion Science and Technology and the Institute of Marine Engineers. But these societies tend to have a wide range of activities, and the role of helping to solve problems directly is usually not a major activity. Several European countries have large central corrosion centers, such as CEBELCOR in Belgium (see Bernstein *ESN* 32-4:136), but these are primarily for research, with consulting secondary. Thus it is probably safe to say that NCS is unique in its role as a government consulting service and unique in the network of associated service centers into which it is integrated. Purveyors of rust in Britain, beware!
(Jeff Perkins)

A GLIMPSE AT CHEMICAL RESEARCH IN THE LOW COUNTRIES

Aspects of chemical research in the Low Countries were sampled in the Spring of 1978 during the course of a series of visits to the University of Amsterdam, the University of Leiden, the Technical University of Delft, the University of Leuven, and the Free University of Brussels.

Brussels—Despite the award of the latest Nobel Prize in Chemistry to one of the Faculty, chemistry at the Free University of Brussels is in some difficulty. Nobel laureate Prof. I. Prigogine with his interests in statistical mechanics which were covered in a recent *ESN* article by Lessen (*ESN* 32-8: 279) appears to have the only sizeable chemical research program at the University. In general, however, there are very few undergraduate students in chemistry, and Prof. J. Nasielski, who holds a chair in organic chemistry, has no graduate students at present. He has recently become interested in research in solar energy and has a research group of four working on this subject. Dr. Andree DeMesmacker-Kirsch, who acts as leader of this group, filled me in on the program. The problem is being approached by photoelectrochemical techniques, and attempts are being made to understand the mechanisms of "super sensitizers" (e.g., hydroquinone) that can effect a 10-50 fold increase in current when added to a solution of a suitable dye (e.g., rhodamin-B) in an electrochemical cell, using semiconductor electrodes. There are two possible mechanisms for the effect: the first involves energy transfer by quenching and the other, the re-generation of the dye by direct reaction with the reducing "super-sensitizer." They are using stannic oxide as the semiconducting electrode and also a variety of dyes, e.g., crystal violet, methyl violet, and malachite green.

The other Professor of Organic Chemistry at the Free University of Brussels is R.H. Martin, who has been working with polyhelicenes. In physical chemistry Prof. G. Verhagen is interested in quantum chemistry and Prof. R. Colin has been involved in research on the kinetics of the reactions of diatomic molecules.

Leuven—At the Flemish speaking Catholic University of Leuven some 15 miles distant from Brussels, the shortage of students is not as marked as at Brussels. Here chemistry is housed in a spacious modern building built about 10 years ago, and Prof. G. Smets, the senior man in the Department, is a world authority on photopolymerization. Prof. F. de Schryver, my host, has research going on in four areas. The first involves the photochemistry of biologically important materials: Coumarins, dicoumarins, indoles, and morphine-related molecules. De Schryver is particularly interested in correlating chemical structure with the receptor sites in the brain and carries out much of his research in cooperation with a colleague in the dermatology department. His second area of interest involves photochemistry in "organized systems," in this instance micelles. This is a relatively new area for de Schryver and involves study of energy transfer with micelles that contain both donor and acceptor groupings incorporated in the molecule. It has been found that in some of these redox systems an electron is ejected from the micelles after excitation. A third research area involves studies of the relaxation of excited molecules and in particular the study of the various competing processes (intersystem crossing, ring-formation fluorescence, and isomerization) for a variety of tetraphenylethylenes. By use of single photon-counting and nanosecond laser flash, emission from two S_1 states has been found: a short-lived emission from the Franck-Condon state and another from the relaxed S_1 state, and the effect of substituents on the rates of these processes is now being studied. The fourth area in which the research group of 15 people is active involves the photochemistry of bichromophoric systems which may lead to photopolymerization by a singlet, triplet, or a mixed mechanism. Thus they have obtained a polyanthracene (polymerized in the 9-10 positions) from dianthracene, and they have also suceeded in obtaining some evidence for the photocopolymerization of certain suitable substrates.

Delft—The Chemistry Department at the Technical University of Delft is housed in a thirty-year old building in the center of town. There are three professors in organic chemistry: Prof. H.C. Beyerman's research concerns peptides and alkaloids, mainly from a synthetic

point of view; Prof. H. van Bekkum is interested in hydrogenation reactions, catalysis, and the coordination of organic transition metals; and my host Prof. B.M. Wepster, is a leader in the field of theoretical organical chemistry. According to Wepster the shortage of students interested in chemistry is also strongly felt at Delft, and he has only one graduate student working with him. His interests cover a very broad range of problems in physical organic chemistry, including Hammett-type correlations, and stereochemistry. Most recently he has been extensively involved in computer modeling of stereochemical problems. These have involved valence-force field calculations, calculations of dipole-moments, and the stereochemistry of organic molecules by beginning with a hypothetical structure and feeding in various strain-steric effects. In stereochemistry, interests have been in the study of the conformations of di-t-butyl cyclohexane by looking at the temperature dependence of the NMR spectra. The Department has a well-equipped NMR laboratory which is under the direction of Dr. A. Sinnema.

Leiden—In terms of facilities, the highlight of my visits was the University of Leiden. Here I found the Chemistry Department (combined with pharmacology) housed in an eight-year old modern ten-story building with a commanding view of the city and the ocean. The building was constructed in the outskirts of Leiden (along with a number of other science buildings) when the enrollment of students was going up, and was built with further expansion in mind. Alas, with enrollment dropping, not only is the building too large, but the number of faculty members, 90, is too high. Prof. Egbert Havinga, the senior professor in organic chemistry and the person responsible for construction of the building, was out of the country on the day of my visit, but he had arranged to have colleagues discuss the research activities in both organic chemistry and photochemistry, the areas of his personal involvement. Havinga's colleague as professor of organic chemistry, Prof. Klosterziel's interests concern the reactions of organic carbanions. His research group studies these by means of NMR (H^1 and C^{13}) spectroscopy. The carbanions, usually prepared by proton abstraction by means of potassium amide in ammonia, give very simple NMR spectra that are drastically different from the spectra of the neutral parent molecules. Klosterziel has also been interested in base-catalyzed electrocyclic ring-opening reactions of heterocyclic compounds. Dr. G. Lodder works closely with Havinga on photo-substitution reactions of aromatic hydrocarbons in acid media. They find that under these conditions the normal rules of orientation do not hold and that most of the substitution occurs in the ortho-position followed by the meta- and para-substituted product. The reaction usually proceeds through the S_1 state. Dr. J. Lugtenburg's interests are more biologically oriented; including the chemistry of vision and of the bile pigments. On the physical photochemistry side Dr. Varma has pico-second laser flash capability (a frequency quadrupled Nd-laser) to investigate some of the primary photochemical/photophysical processes that occur with aromatic compounds in a condensed phase. In this way they have been studying the behavior of some dinitro-substituted aromatics, a phototropic tetrachloro-keto-dihydronaphthalene, and have been particularly interested in studying the effect of solvent on the rates of excited state processes. Still more physically oriented is Dr. Dekkers' research. He is involved in both theoretical and experimental studies of the MCD and circularly polarized luminescence of optically active organic molecules. He finds that from the difference observed between the MCD and the circularly polarized luminescence one can deduce differences in geometries of the ground state and the luminescent excited state. Although to date he is working only with optically active compounds containing an asymmetric center, he appeared to be interested in the suggestion that some optically active biphenyls would be worthy of study by his methods.

Amsterdam—Physical chemistry at the University of Amsterdam is in process of moving into a new building very near the old site, and the Laboratory of Electrochemistry will soon be merged with it. Professor J.A.A. Ketelaar has been head of this Laboratory for many years except for a seven-year break in industry in the early 60's. Ketelaar will retire in 1979 after a career that spans over four decades, but he will continue to participate in some of the EEC advisory bodies in the field of energy.

His university research has mainly concerned studies of fused salts, particularly of the transport properties, diffusion and mobility of ions. He developed a rather simple technique using quartz-fiber filter papers that are impregnated with the molten salt and in which the mobilities of the ions can be determined, frequently using labeled ions for this purpose. Mobility depends on the medium and also on the size of the cation. When the medium is a mixed salt, crossing in mobilities with size is observed. In addition to experimental work, molecular dynamics have been used for modeling these systems, the calculated diffusion coefficients agreeing well with the experimental data.

Ketelaar and his colleagues have done research on mixed alkali-chloride cadmium-chloride salts from the standpoint of complex formation and have been interested in determining conductivities in molten salts. They have found that quartz becomes conductive in molten sodium chloride, for example. They have been experimenting with the use of nitrate and sulphate electrodes that can be used in molten salt medium. They also find that monovalent molten salts behave like ideal liquids, perhaps because potassium chloride is isoelectronic with argon. As a somewhat related but different interest, Ketelaar has also recently been involved with some research on the chemistry of cements.

The Physical Chemistry Laboratory at the University of Amsterdam has six faculty positions under the overall direction of Professor J.D.W. van Voorst. In addition there are 18 temporary teaching positions. The research interests include the dynamics of energy transfer, laser relaxation studies of phase memory by means of picosecond laser spectroscopy, molecular dynamics in liquids (theoretical and experimental), photon-echo studies in the gas phase, and work on phase relationships in the solid phase by optically detected magnetic resonance. The Laboratory has excellent instrumentation including a Fourier-transform infrared spectrometer, ESR and microwave spectrometers, and a variety of laser instruments that include picosecond laser flash capability. In the research on phase relaxation they are working with small gas molecules such as nitrogen, noble gases, chlorine, and carbon monoxide, studying the selection rules and learning what vibrations are involved in the relaxation process. They are also involved in dephasing by laser absorption spectroscopy. Nitrogen shows solvent-induced dephasing with a rate of 10^{11} in liquid argon. These results are being compared with theoretical molecular dynamics calculations. In the solid phase they have been studying crystals doped with large aromatic molecules and the behavior of symmetrical tetrazine. For the latter they find that the lifetime depends on a particular vibrational level of the S_1 state that had been excited. They have been studying calcium oxide in the solid phase by microwave techniques and find that there are three Jahn-Teller triplet states for this molecule. These techniques are now being extended to some other semiconducting compounds. Some research here has a biochemical slant, is in collaboration with the biochemistry department, and covers nanosecond laser flash studies on flavines, flavo-proteins, and enzymes.

In the Laboratory of Organic Chemistry (which will remain on Nieuwe Prinsengracht) Professor Th. J. de Boer and his associates are doing research in three areas: The chemistry of small ring compounds, chemistry of organic nitroso compounds, and organic photochemistry. De Boer has found a convenient method for the synthesis of cyclopropanone by reaction of ketene and diazomethane. The compound is unstable, but when the reaction is carried out in methanol the hemiacetal is relatively stable and shows typical reactions. In the synthesis of some nitroso compounds and nitrones they have found that the reaction of oximes with chlorine is a good starting point. They have been studying the photochemical oxidation of nitroso compounds to nitrates which appears to be going through free-radical intermediates. In the photochemistry area, Dr. Cerfontaine has been studying polyfunctional carbonyl compounds, with an emphasis on α-diketones. Comparison of the fluorescence emission and the absorption spectra suggests that in their excited singlet states six and seven membered-ring α-diketones are planar, in contrast with the ground states. In addition, they have been studying some conjugated carbonyl compounds (e.g., ionones) that appear to photoisomerize through the triplet states.

As in Italy (see *ESN* 32-9) chemistry in the universities in the low countries has its student problems.

Here, however, the problem is one of a declining number of students which has resulted in some excellent facilities planned or built a decade or so ago for an expanding student body now being sparsely occupied. This student problem has already hit the research level, where among some research groups there are now few or no research students. The quality of research nevertheless remains high. [George M. Wyman, US Army Research and Standardization Group (Europe)]

MATHEMATICAL SCIENCES

SCHOOL ON VARIATIONAL INEQUALITIES AND COMPLEMENTARY PROBLEMS IN MATHEMATICAL PHYSICS AND ECONOMICS

The "Ettore Majorana" Centre for Scientific Culture in Erice—a poetic medieval city in a remote corner of Sicily—was the location for an International School of Mathematics. Held from 19-30 June 1978, the School concentrated on the theme of variational inequalities and complementarity problems in mathematical physics and economics. The idea for a school on these subjects came from Guido Stampacchia, Franco Giannessi, and the author of this note. Our objective was to assemble numerous leading researchers in these two related but seldom communicating branches of Mathematical Science in order to promote further interaction among and between the two groups.

Altogether the School was attended by about 60 participants from 15 countries, principally from Italy, France, and the United States. As is the custom at the Ettore Majorana Centre where schools are held on a year-round basis, the participants were all classified as invited speakers or else as "students." In actual fact, none of the latter were students in the conventional sense, but rather PhD holders with mathematical publications to their credit. Several of these individuals contributed supplementary lectures during free afternoon periods. In short, the level of the attendees was quite high.

Unfortunately, Prof. Guido Stampacchia (Scuola Normale Superiore, Pisa) died less than two months before the beginning of the school. His absence undoubtedly affected the scientific direction as well as the mood of the School—especially at the outset. However, Prof. J.L. Lions (Laboratoire de Recherche en Informatique et Automatique, Rocquencourt, France), one of the invited speakers, abandoned his originally planned topic and presented instead two brilliant lectures reviewing Stampacchia's contributions in variational inequalities. In so doing, he set both an appropriate memorial tone and a scientific foundation for a number of the lectures which followed.

A variational inequality problem can be viewed as a constrained optimization of a particular form. The ingredients are typically a real Hilbert space V with dual space V^*, a nonempty closed convex set K in V, a bilinear form $a(\cdot,\cdot)$ on $V \times V$, and an element f of V^*. One seeks an element $u \in K$ such that $a(u,v-u) \geq (f,v-u)$ for all $v \in K$. In this setting the complementarity problem is generally stated with reference to a closed convex cone κ and a given mapping $F: V \to V^*$. One seeks an element $u \in K$ such that $F(u) \in K^*$ (the polar of κ) and $(F)u,u)=0$. So stated, the complementarity problem and the variational inequality problem have the same solutions, if any. It should be noted however, that the variational inequality problem need not be stated with reference to a cone, so in this sense, it is a more general problem.

Although the two types of problems have much in common, there has been little direct contact between researchers in these two fields. One possible reason for this might be that the study of variational inequality problems has been centered in Europe—especially in France and Italy—whereas work on complementarity problems (and related fixed point methods) has developed mainly in the United States. But modern communication and transportation facilities make this explanation inadequate. A more plausible argument may have to do with the backgrounds of the mathematical scientists concerned. Although there are numerous exceptions, the variational inequality people tend to be educated in the tradition of classical applied mathematics. Models of physical problems, differential equations, and topological vector spaces are common elements of their work. The complementarity people—again, with some exceptions—lie closer to the younger branches of mathematical science such as operations research and combinatorics.

Their efforts are closely related to mathematical programming which most often is motivated by management or economic problems and is mainly finite-dimensional.

These differences in orientation were apparent in the lectures. Issues such as the existence and uniqueness of solutions are of interest to both groups, but questions like the appropriate function space in which to seek a solution do not arise in the finite dimensional setting. On the basis of the lectures presented at the School, it might be inferred that numerical algorithms play a much larger role in the complementarity field than in variational inequalities. However, this distinction can to some extent be attributed to the selection of the lecturers. There is far more activity going on in the numerical solution and analysis of variational inequalities than one might have imagined at the school.

Many of the lectures—particularly those concerned with variational inequalities—covered such topics as free boundary problems. These arise in the study of flow through porous media, hydrodynamic lubrication, and elasto-plastic analysis. The lectures on complementarity dealt with algorithms, existence theory, and relationships between complementarity problems, variational inequalities, mathematical programming, and monotone operator theory. Other theoretical lectures represented the calculus of variations, stochastic optimization and control, convex analysis, and systems of nonlinear equations. The applications discussed tended to lean more toward physical than economic science. One particularly interesting application in the complementarity field possessed both physical and economic ramifications. It was concerned with the optimal excavation of submarine pipelines.

As already mentioned, the study of variational inequalities is strongest in France and Italy. In Italy, there is also considerable interest in complementarity systems. This interest cuts across all lines of activity: theory, computation, and application. The Italian leadership can be expected to continue in the future, largely through the efforts of E. Magenes (Pavia), U. Mosco (Rome), F. Giannessi (Pisa), and G. Maier (Milan). These individuals and the groups they head bear the capacity to coordinate the developments in France, America, and elsewhere with contributions of their own.

It is worthwhile repeating here what has been said many times before: small gatherings of specialists for relatively long periods of time in secluded places are beneficial to the advancement of knowledge. This School on variations inequalities and complementarity problems was no exception. It had no parallel sessions, no serious distractions, and no time pressure to interfere with the subjects at hand. During the nearly two weeks of this School many new contacts were made, many stimulating ideas were exchanged, and several collaborations were begun. These are just the sorts of benefits that were anticipated by the organizers of the school. A volume of Proceedings (dedicated to Stampacchia) is foreseen. (Richard W. Cottle, Stanford University, Palo Alto, CA)

INTRODUCING NORSK DATA TO AMERICA

The Norwegian Defense Research Establishment (NDRE) and the Royal Norwegian Council for Scientific and Industrial Research have for decades supported R&D on digital computers. Perhaps the best-known of Norwegian computer manufacturers is Kongsberg, which is fully government-owned. However, the fastest growing and most dynamic of Norwegian computer companies is the privately owned Norsk Data A/S, which is headquartered in Oslo.

Norsk Data (ND) is an excellent example of the Norwegian's ability to carry through from fundamental research to prototype development and testing within a government-subsidized laboratory and then to spin-off the new technology into the private sector of the economy for commercial development. (This is in marked contrast to the often heard stories of R&D projects in some other countries which show great promise for commercial development but, for whatever reasons, never see the light of day outside the laboratory.)

In 1967, three people from the Electronics Section, NDRE, with the encouragement of the Government, left NDRE to form their own company, Norsk Data. Their objectives were to design, produce, and sell digital computers and peripheral equipment. Although the first few years

were mainly devoted to further R&D and some initial product development, ND's growth was not rapid. During these years, the newly developed computers were built in small series involving simple test equipment and were sold to customers who themselves had a detailed knowledge of data processing, e.g., firms having the capability of developing their own operating system software and interfaces to peripheral input/output equipment and auxiliary storage devices such as tape or disk drives.

Obviously, this is a rather limited and specialized market, and ND realized that sustained growth would depend upon designing complete hardware and software systems which could be easily manufactured and serviced, and which would have a reasonable technological life span; that is, systems which would not be quickly out-dated by superior equipment appearing on the market in the fast-paced and highly competitive computer industry.

Thus, ND's basic policy has always been to make use of the latest technology to develop products which will give a customer the best possible overall solution to his data processing requirements. This policy has led to an interesting combination of product standardization—which permits mass production—and custom-tailoring to the precise needs of the customer.

The actual machines produced by ND go by the name of NORD computers. They are of the so-called minicomputer type, in contrast to the very large mainframe machines produced, for example, by IBM and Control Data. An interesting fact which my host Mr. Åsmund Sløgedal (Vice President of International Operations) pointed out is that the rapid market growth for computers seems relatively little influenced by variations in overall economic conditions. For instance, the worldwide growth rate for large mainframes has been consistently about 15% per year, while for minis the market shows a 30-35% per year increase. This latter figure certainly augers well for Norsk Data.

Modularity of both hardware and software designs is the key to ND's ability to respond quickly to changing market demands and easily to incorporate new and improved electronic components, especially large-scale integrated circuits that are purchased principally from American electronic firms. Similarly, ND buys virtually all of its peripheral equipment from the leading manufacturers around the world. The NORD computer itself (i.e., the central processing unit, memory units, and all equipment needed to interface with peripherals) is designed, developed, and manufactured by ND as are the basic operating systems, compilers, and data-base management systems.

However, ND does not attempt to develop applications software for the specific problems of their customers. This seems a wise policy, since today most organizations either have their own in-house applications software or can purchase good packages from so-called software houses. One exception to this policy, which is presently being negotiated, is the possibility of ND purchasing the NAG Library (Numerical Algorithms Group) of basic numerical algorithms which would well serve the needs of most engineering and scientific users. (For more information on the British-developed NAG Library, see *ESN* 31-2:54 by this author.)

The early NORD hardware and software systems were designed specifically for engineering and scientific computing applications and were sold primarily to universities and research institutions. However, as the equipment became increasingly sophisticated, ND successfully entered the commercial data processing market as well, and a growing proportion of their sales are in this sector.

ND's three basic computer series are the NORD-10, NORD-12, and the NORD-50. In brief and broad outline their respective technical specifications are as follows: NORD-10 is a general-purpose, medium-scale computer with 16-bit wordlength. It has MOS virtual memory with up to 256k word capacity, a memory management system with unique data protection features, a microprogrammed instruction repetoire, and 16 independent program levels. NORD-12 is a smaller version of the NORD-10 with up to 64k words of memory. NORD-50 is a special high-speed arithmetic unit working as a slave to the NORD-10. The NORD-50 works with 32-bit words, but can also have 64-bit floating point accuracy without reduction in speed.

The operating system and data-base management system software offered on NORD machines are termed SINTRAN III and SIBAS, respectively. The SIBAS data-base system, originally developed by the Central Institute for Industrial

Research in Oslo, is claimed to be the first full-fledged data-base system following the CODASYL DBTG recommendations to have been implemented on a minicomputer. It is identical to the systems offered on large mainframe machines such as the UNIVAC-1100 and IBM 360 and 370 series. ND's implementation of SIBAS has utilized facilities of the SINTRAN III virtual storage operating system in order to minimize the number of additional routines required in the programs. It provides the capability for multiple user-programs to access the same data-base simultaneously, and at the same time it prevents any single user from intentionally or inadvertently contaminating the common data-base.

Last year was an especially profitable and eventful one for ND. Total sales in 1977 amounted to 115.5 million kroner (approximately $23 million). Although slightly more than half of these were to Norwegian and Swedish organizations, sales in France, Switzerland, Germany, and the US accounted for nearly 40% of the total. ND is especially proud to have broken, for the first time, into the American market with the sale to Singer Link of NORD systems for the flight simulators of the F-16. Another source of pride is the fact that CERN (the European Organization for Nuclear Research), which in 1973 was the first European organization to purchase NORD computers, has ordered an additional 26 machines. Altogether, CERN now has nearly 100 NORD computers. As a result of having increased its export sales from none in 1972 to 46% in 1977, ND was awarded the "1977 Norwegian Export Award."

In connection with the export market, ND and all Norwegian companies operate under two major handicaps. Aside from the comparatively aggressive marketing policies of their major competitors (mostly American-based companies), every European country that has its own computer industry has rather strong economic protectionist policies that essentially preclude any government subsidized organization from buying foreign manufactured equipment. Thus, ND must direct most of its sales effort toward the private sector of the European market. (Ironically, Norway itself is one of the least economically protectionist countries in Europe, since by law all Norwegian companies must bid for public contracts on the same terms as their foreign competitors.)

Its second major handicap is that Norway is a very high cost country compared to most European nations. In expanding it's European operations, ND feels that this factor will be partially offset by the fact that almost half the labor cost associated with the production and sale of their equipment is accounted for by marketing and support in the user's own country.

Because of the excellent reception that NORD computers have received in the past several years and the company's desire to expand further, Norsk Data is experiencing growing pains. From the original three founders in 1967, the company has grown to more than 500 employees, with approximately 220 in Oslo and the remainder at several branch offices. In the past four years alone, the number of employees has increased from 100 to the current 300 plus, and the first of the five major branch offices was not even opened until mid-1975. During my visit, preparations were in progress to move—for the fourth time—to new and much larger headquarters.

Such growing pains are, of course, common to any very successful small enterprise; but, in Norway there are some unique problems. For example, the Norwegian unemployment rate is less than 1%. There is a great shortage of labor—both skilled and unskilled. In particular, people with prior experience or advanced level education in high technology areas are in great demand and short supply throughout the country. Because of this, ND feels that it may be necessary to move certain of its operations to subsidiaries in other countries where there are better prospects of finding qualified personnel.

In addition to its headquarters in Oslo, Norsk Data has branch offices in the UK, France, Denmark, and Sweden. Recently, it has opened an American branch office in Boston from which it hopes to make further inroads into the US market. (William J. Gordon)

ONRL REPORTS

See the back of this issue for abstracts of current reports.

MINICOMPUTERS, MICROCOMPUTERS AND THEIR APPLICATIONS

The International Society of Mini- and Microcomputers held its Sixth Symposium and Exhibition in Zurich on 12-15 June 1978. The setting was unusual being several rooms of a small hall on a back street, more often used for ballet practice and music school recitals, and indeed trumpet practice was underway in one of the adjacent rooms throughout the Conference. Nevertheless, the Conference content was good, despite many papers being cancelled at the last minute. Of particular note were papers discussing hardware and software from countries not frequently heard from, there being four papers from both Hungary and Spain and one each from Finland, Czechoslovakia and Poland. Most of the announced papers as usual, were from the US, Canada, the FRG, France, and Switzerland, but to a disappointing extent US speakers failed to arrive. I will restrict my coverage of the Symposium to a few highlights with special attention to contributions from the countries rarely heard from.

Prof. D. Zissos (Univ. of Calgary, Canada) offered a tutorial on methodology for system design using microprocessors. He progressed through the usual procedural steps and cast some extra light on each. For example, his first step was "Define the System Purpose," and in this he advocated developing a statement of objectives which was a more general statement than the originally stated problem. He stressed that the fundamental considerations in application of microprocessors are their limited power and the need, therefore, for time sharing or multiplexing to accomplish a function. He defined the microprocessor as simply a program-driven clocked sequential circuit, and described the various methods of asynchronous time multiplexing, namely:

Wait-and-go, which calls for appropriate wait and go lines to be built into the microprocessor logic.

Test-and-skip, which uses the same wait and go logic to poll other devices.

Interrupt, which requires somewhat more elaborate wait, go, and flag logic, and

Direct Memory Access.

Zissos proceeded to observe that the microprocessor is making it possible to return to the values of the 1950s when the inner workings of the computer were visible to all. He pointed out that the development of the 1960s and early 70s created an envelope of software around the computer that denied direct access to the electronics to all unauthorized personnel—and that hardware engineers are by definition unauthorized. He called the software a layer of "administrators," and stressed that with microprocessors the administrators are now gone, thus leaving the way open to engineers to design with hardware and software tradeoffs once again.

The analogy between this view and those of Prof. Robert Anthony of MIT are striking. Students of industrial management in the early post-WWII period will remember that Anthony described how industrial organizations grow through centralization of decentralized capabilities followed by a proliferation of further decentralization of new capability, followed by a new wave of centralization. In the computer case, processing power is centralized in the standard software, which indeed grew enormously from 1960 to 1975 and required application programs to rest on bigger and bigger computers and more and more executive and utility software. The computer business became a high-overhead business, but now microprocessors have brought back a low-overhead world where the designer can make direct connections between the basic building blocks and his own problems.

Gyorgy Ambrozy (Central Research Institute of Budapest, Hungary) reported on a project to design and build a microprocessor system that would have all the characteristics of a general purpose computer and could emulate several of them. He described a system built of Intel 3000 bit slice-components and said it had now successfully emulated a PDP 11/40 using two printed circuit boards only, in contrast to the nine of the 11/40, and with an average execution time slower only by a factor of 1.5.

Pyotr Magerski (Univ. of Prague, Czechoslovakia) described techniques for increasing speed through pipelining at the microinstruction level when the CPU cycle time is more than twice as fast as memory access time. By duplicating the Memory Address modules and multiplexing the interface between two or more Read Only Memories, it is possible greatly to reduce the time required to

execute instructions with only a very small increase in the number of printed circuit boards required.

S. Takahashi (Hitachi Ltd's Central Research Laboratory, Japan) gave a paper on memory extension in microprocessors. This was really only a description of the HITAX 20 which implements a method whereby its 16-bit microprocessor logic can address as much memory as would normally require 32 bits, namely 256,000 words of memory. Takahashi argued that the approach of using a 16-bit machine with additional logic was a better solution than going to a 32-bit machine because of compatibility considerations with existing designs, and provides reasonable performance with less overall circuitry. This does not seem terribly controversial, since the INTEL 8086 and Zilog Z8000 microprocessors seem to be following the same general approach. In any case Takahashi acknowledged that the limitations of this approach are limited applications enhancement capability, control program duality, and address translation overhead. This writer speculates that such a 16-bit machine memory extension may be an important interim step toward 32-bit machines.

Stefan Tomann (Siemens, Munich, FRG) described in depth (in German) the Siemens 128 microprocessor array SMS 201. The SMS 201 contains 128 modules, each of which consists of a microprocessor with two associated memory units, one for private memory and the other for communication. The modules are connected to a main processor via an interconnection memory bus. After completing their individual tasks, the modules synchronize themselves autonomously for data exchange by initiating the main processor that controls the data exchange between modules, distributes new tasks, and restarts the modules.

In each module the microprocessor uses its own private memory to store the intermediate results of individual calculations but stores the final result in its portion of the communication memory, and at the same time flags the main processor to initiate the data exchange. During data exchange the main processor distributes the results of each module to all other modules. Thus all communication memories have all the data of all other modules. The data exchange is thus completed very rapidly. This technique requires excess memory, but Siemens feel the tradeoff warranted.

Primary constraints are that 1) the number of operations per module task should be of the same order otherwise the excess processing power is wasted, and 2) the task length should be great compared to the data exchange time.

At present the SMS 201 system has been programmed to accept current weather conditions in the European region and numerically forecast the weather in five-minute steps. Other applications planned for the SMS 201 include circuit simulation, image processing, process control, and environmental simulation.

Herr H. Roethlisberger (Swiss Federal Institute of Technology, Lausanne) described his approach in assembling an array of microprocessors to form a general purpose system. His system uses two busses, one for addresses, the other for data. Each microprocessor has access to a local memory and local IO as well as to a larger shared memory and shared input output equipment.

Dr. Adam Osborne (Osborne and Associates, Berkeley, CA) gave the key invited paper, an analysis of whether and to what extent microprocessors will be displacing and obsoleting minicomputers during the remainder of the 20th century. He asserted that redesign costs will be so great that current minicomputer users will not shift rapidly, thus preventing obsolescence. Because so many users will be captives of their present design, he predicted that minicomputer sales will continue to increase for several years, level off at about 1980, and taper out at about the turn of the century.

He then offered an in-depth description of two microprocessors that have been announced but are not yet available, the INTEL 8086 and the Zilog Z8000. Both designed for array or network use, they are first members of a new class of product and not the last of an existing one. The Z8000 is capable of being expanded and of becoming equivalent to an IBM 370 on a single chip. The 8086 will be available for delivery later this year and consists of a CPU and a Bus Control Unit both located together on a single chip. The Z8000 will be a year later. Both the 8086 and the Z8000 implement logic of the general sort described by Takahashi to permit memory extension beyond the 16 bit limit. Both are US developments and ahead of anything to be found in Europe.

Lehtinnen and Nikkila (Helsinki Uni-Univ. of Technology, Finland) discussed reliability of their MUMI dual bus

multicomputer system. They developed a mathematical model for hardware failure rates and analyzed their design using the model to compare reliability of the system as it might be implemented using commercial or militarized integrated circuit chips. Their comparison between actual and calculated failure rates led them to conclude that (US) military failure rates for dense large-scale integration are too pessimistic.

Szendi and Szentes (Hungarian Central Research Institute for Applied Computer Science) described GENAX, a modest interactive system designed and built for data acquisition in a multitasking environment. The system is now operational both in Hungary and Russia, being used by the Soviet Ministry of Transport and the Hungarian State Railway System. The Hungarian version consists of a Hungarian R10 minicomputer and six CRT terminals (2 synchronous, 4 asynchronous) and is used for queries on times of arrival and departure of trains throughout the system. No discussion was offered of data entry or indeed of the benefit obtained from the use of the system which does not appear in any sense to be a revolutionary advance.

A. Szegi (Polytechnic Univ. of Budapest, Hungary) spoke briefly of a universal development system built at the Polytechnic and then described in greater depth his own work on a Condition Generator using a small RAM instead of the Comparator more conventionally used for such applications. He claimed more services without appreciably more circuitry employing 25 chips and a 256 K MOS RAM, although bipolar memories would be required for higher speed operations.

The conference as a whole was worthy of attention because of the many offerings by young researchers from countries not in the forefront of technology. It could have been better but suffered from the failure of a number of the programmed speakers to appear, regrettably including several from the US. [George M. Sokol, US Army Research and Standardization Group (Europe)]

MECHANICS

GAS DYNAMICS AT THE INSTITUT FRANCO-ALLEMAND DE RECHERCHES DE SAINT LOUIS (ISL)

The Franco-German Research Institute of St. Louis, established shortly after WWII as a cooperative enterprise between France and West Germany, has been described a number of times in *ESN* and most recently by R.H. Nunn (*ESN* 30-11: 504). Although ballistics research has been and remains an important function of this Institute, Prof. Herbert Oertel, who also holds a chair at the Technical University of Karlsruhe, is engaged in studying noise from supersonic jets. The motivation for this research is, of course, the noise problem associated with the Concorde.

An important facility of the Institute is the shock tube laboratory, where there are two long shock tubes with an inner diameter of 10 cm and the capability of 1500-atm pressure and 4000-K temperatures in the drive chamber which with hydrogen as the driving gas can produce Mach numbers of 15. The shock tubes are currently being used as shock tunnels. There are a number of different modes in which a shock tube can be used as a shock tunnel, and the one in use in St. Louis places a convergent-divergent nozzle at the driven end of the tube opposite the driver. When the shock wave is reflected from the nozzle end of the tube, there ensues a high pressure region behind the nozzle which causes supersonic flow at the nozzle exit.

Oertel and his coworkers have been concentrating on the near field of the jet and the surrounding fluid. The near field is defined as that region in which the potential core of the jet has not been eradicated by mixing processes. Oertel has found that the near field of a supersonic jet radiates a large amount of noise, and it is the mechanism of this noise generation and radiation in a turbulent jet that interests him. One reason for the radiation of sound from supersonic shearing layers is that a self-excited disturbance of the shearing layer with a phase velocity that is supersonic relative to the external flow will cause bow waves in the disturbance flow similar to those associated with a projectile moving through the air at supersonic

velocity. These bow waves extract energy from the disturbance causing the flow to be more stable than it would be if the disturbance were subsonic. The minimum critical Reynolds number of such a flow is hence greater than it would be in the subsonic case, and the angle of spread in the mixing region is therefore smaller. This phenonemon causes the near field of such a jet to be longer than it would be in the case of a subsonic jet, with the result that the sound radiated by the near field is greater. It also follows that the sound radiated by the far field is correspondingly greater as well. In actual fact, Oertel has found three sets of disturbance characteristics associated with the near field of the jet shearing layer, and it seems that these individually may be associated with an irregularity in the primary jet flow and with waves caused by the interface disturbances in the primary and secondary flows, respectively. Oertel has taken many photographs of the near flow fields under many different conditions. All show that the turbulence seems to be a very well-ordered disturbance.

In our discussions on supersonic flow over cones with attached shock waves, Oertel observed that all photographs that he has taken of such flows show Mach lines behind the bow shock. These Mach lines have often been associated with roughness of the cone causing disturbances to propagate out from the cone into the surrounding flow. However, curiously, the angle of these Mach lines does not relate to the velocity of the shock layer in the way that it should in these circumstances. Rather it suggests that whatever is causing the disturbance is moving at a lower supersonic velocity relative to the fluid in the shock layer than the velocity of the fluid relative to the boundary. Oertel interprets the causes as large-scale coherent turbulent structures in the boundary layer about the cone which move downstream at a velocity intermediate between that outside the boundary layer and the wall velocity. The Mach number of the flow outside the boundary layer relative to the large-scale structures is therefore less than that of the flow outside the boundary layer relative to the cone surface, and hence the Mach angle of the former is greater. Another interesting observation by Oertel concerns the starting donut-shaped vortex outside the exit of a shock tube in starting flow. Oertel has taken pictures of this vortex that indicate streaks oriented in an axial direction and spaced regularly and azimuthally around the periphery. The interpretation of these streaks seem to indicate the presence of a convective instability in Goertler vortices.

An additional area of interest at the laboratory is the influence of film condensation on heat transfer in the boundary layer. In this study a tube concentric with the shock tube is placed inside it and the shock wave passed in the annulus between the two tubes. The shock Mach number produced is approximately 6, the velocity behind the shock wave is 2000 m/sec, and the temperature of the fluid behind the shock wave is 2000 K. The fluid consists of a mixture of water vapor and air of varying concentration. The tube is chilled so that the vapor condenses against the tube. It is noted that immediately behind the shock the presence of condensation causes a ten-fold increase in the heat transfer rate whereas far downstream from the shock, the heat transfer rate is only increased by 20% as a result of the condensation.

Some of the many beautiful photographs that Oertel had taken in his study of high-speed turbulent jets indicated a sinusoidal kink mode of instability of the flow. I urged Oertel to continue these studies and in particular to see whether he could find any self-excited disturbance mode in the far-field large-scale structures as well. (Martin Lessen)

LABORATOIRE AÉROTHERMIQUE DU CNRS

The Laboratoire Aérothermique sponsored by the Centre National de Recherche Scientifique (CNRS) is located in Meudon, France, at the southwest edge of Paris. The Laboratory is under the direction of Prof. J.J. Bernard, who also holds a chair in Theoretical Applied Mechanics at the Univ. of Paris VI. Bernard and his associates graciously showed me about the Laboratory and discussed the on-going research which is concerned in large part with the mechanics and physics of fluids.

An outstanding facility in the laboratory is a low-density wind tunnel, denoted SR3, that can work to pressures as low as 10^{-3} mm of mercury and that

has a flow velocity range of subsonic to Mach 30. The useful portion of the flow is 200 mm in diam. Electron gun and spectrometer instrumentation are available to obtain temperature, density, and rotational temperature of a flow field. Velocity is obtained using the time of flight of ionized particles. The working gas is nitrogen. In three smaller low-density tunnels, one of which was the prototype for the SR3, flows up to Mach 7 can be studied; the working gases in this facility are nitrogen, argon, helium, and neon, and the tunnel is fed by a plasma jet with a stagnation temperature of the order of 4000°C. A second of these smaller tunnels is used in the study of ionization and recombination processes with reactions being observed by spectrometer and electron gun techniques. The chemical kinetics of two different components are studied by injecting a jet of one gas inside the jet of another. Another exercise studied in one of the small tunnels concerns the ionization effect of water injection on the principal flow.

The study of convective instabilities is now quite popular in some facilities in Europe, and this Laboratory is contributing in this area. There is an experimental program that is studying convective instabilities for various geometries and for unsteady boundary conditions. The working fluid being used is carbon tetrachloride with the addition of tiny glass spheres. Laser anemometry is used in connection with the glass spheres to map out the thermally induced flow patterns. Although the term convective instability is applied to this research, the studies are really involved with secondary flows in finite containers.

The Laboratory also has a super-hypersonic tunnel facility that has a number of different nozzles and test sections for continuous operation over Mach numbers from 2 to 17. At the higher end of the Mach number range, the stagnation temperature of the gas is 1300 K. The cross section of the useful part of the test sections varies from 64 mm diam. for a Mach number of 2 to 50 mm diam. for a Mach number of 17.

A very interesting optical effect has been applied to the visualization of thermal fields in saturated granular media. The medium in this case consists of a combination of particles of Pittsburgh glass and chlorobenzine. These two substances have the same refractive index at a temperature of 31.5°C for light of 6450-Å wavelength. However, the dispersion curves of the solid and liquid phases have different slopes so that for light of wavelength other than that for which the refractive indices of the two substances are identical the combined medium is diffusing. This effect was studied first by C. Christiansen in 1884 and has been used to produce optical filters. Since the coefficient of thermal expansion of a liquid is generally much greater than that of the solid, a variation of temperature produces a translation of the dispersion curve of the liquid that is much greater than that of the solid and a displacement of the critical wavelength corresponding to the point of intersection of the dispersion curve of both media results. This effect can then be used in an optical system to visualize isotherms in the flow field. The method of visualization of isotherms has been applied to the study of natural convection. It can be used in all cases in which the thermal field is two-dimensional. The same technique can also be used for the visualization of lines of concentration in isothermal cells, thus making possible the visualization of diffusion processes of two liquids in the presence of a porous medium. The work was performed by M. Cloupeau and S. Klarsfeld.

An interesting idea being pursued by Cloupeau is the application of electrohydrodynamic techniques to power generation from wind. The idea is to form an electrohydrodynamic generator by placing two grids perpendicular to the direction of the wind with an electrical potential difference between them. If an aerosol of uniformly charged particles of uniform scale is suspended in the wind, power can be collected on the grids by electrodynamic interaction with the particles. Cloupeau is using particles of 1 μm in diameter that have a mobility of 1/50th of that of a molecule of air. In principle, such a scheme should work, however, in practice it is difficult to produce uniform particles with a uniform charge from a cheap material that will not contaminate the environment; water cannot be used because its particles evaporate too rapidly. At present, Cloupeau has tuned his apparatus so that by using a low-speed wind tunnel to provide the wind, he now gets slightly positive power production.

Some studies in turbulence in high temperature flow are being conducted by A. Lasek and I. Gökalp. They have developed techniques in hot wire anemometry permitting study of fluctuations of velocity without the influence of temperature fluctuations on the one hand, and of fluctuations of temperature without the influence of velocity fluctuations on the other.

In addition to its other facilities the Laboratory has a low-speed wind tunnel facility of with a test section 50 cm × 50 cm cross section, that is capable of speeds of up to 50 m/sec. At present the influence of a deformed wall on boundary layer stability is being studied. A flat plate containing a flexible panel that can be displaced 0.5 mm by pressure behind it causes the boundary layer configuration over the panel to change. Two effects are involved; the first is the change of curvature of the flow stream lines within the boundary layer, and the second is to change the velocity distribution in the boundary layer. In this way one can study the effect of wall convexity or concavity on the development of turbulence in the boundary layer. The research will eventually proceed to include the effect of an irregular surface and wall elasticity on boundary layer transition.

In conclusion, I must express my appreciation to Bernard and his staff for having shown me around their Laboratory at a time when most of France was on vacation. (Martin Lessen)

OCEAN SCIENCE

BREAKING WAVES: SURF AND RUN-UP ON BEACHES

In the mid 1960s the European Mechanical Colloquia (EUROMECH) on theoretical and applied mechanics were established for the purpose of bringing together the emerging and practicing scientists in Europe known to be active in a particular subject. The meetings, covering three to five days, are informal with not more than 50 participants. EUROMECH itself is composed of representatives from mechanics organizations throughout Europe and reports to the International Union of Theoretical and Applied Mechanics. There are no formal proceedings of a colloquia; however, each chairman may, if he wishes, publish a summary report of the meeting in a journal.

EUROMECH Colloquium 102, "Breaking waves: surf and run-up on beaches," was held at the Univ. of Bristol over the four days 18-21 July, 1978. It was attended by approximately 40 participants, all working scientists, from Denmark, France, Germany, Greece, Israel, Japan, the Netherlands, Norway, Poland, UK and the US. Visiting participants were lodged in Willis Hall, a dormitory pleasantly located on the Downs about two miles from the University and the site of many unscheduled but stimulating discussions. Scheduled sessions, lunches, and morning and afternoon coffee/tea breaks were held on the grounds of the University itself.

The opening session of the meeting on the afternoon of 18 July, comprised two 75-minute lectures. The first, "Solitary waves in two dimensions" by J.W. Miles (Univ. of California, San Diego) dealt with: the Boussinesq and Korteweg-deVries (KdV) equations for a gradually varying channel, and especially the fact that mass is not conserved by the KdV formulation in consequence of the reflection induced by channel variation; oblique and resonant interactions of solitary waves; and ray theory for solitary waves. The second lecture, "The stability of steep gravity waves, or 'Why do waves break?'" by M.S. Longuet-Higgins (Univ. of Cambridge and Institute of Oceanographic Sciences, Wormley, UK), concerned the instabilities that precede the breaking of two-dimensional, deep-water gravity waves and with the closely related problem of the determination of the highest wave, which is neither the most energetic nor the fastest wave.

The remaining sessions (four on each of 19 and 20 July and two on 21 July) comprised lectures of widely varying duration with ample opportunity for discussion. Among the longer lectures were "A critical review of conventional models for some surf zone phenomena, with special reference to the calculation of nearshore currents" by J.A. Battjes (Technical Univ. of Delft, the Netherlands), "Prebreaking behavior of waves" and "Waves in shoaling water, experimental results" by I.A. Svendsen & J. Buhr Hansen (Technical Univ. of Denmark, Lyngby), and "Fountains, waterfalls and breaking waves" by D.H. Peregrine (Univ. of Bristol, UK). The topics ranged from the purely

analytical (including especially the work on breaking waves by Longuet-Higgins and members of his groups at both Cambridge and IOS) to the outright empirical.

Perhaps the most valuable contributions were the many reports on relatively precise measurements in laboratory wave tanks. It was especially noteworthy (at least for a theoretician such as myself) to learn that computer-programmed wavemakers, transducers, and direct processing of transducer outputs have reached a level of sophistication where data from different laboratories are directly comparable. The interpretation of this data is still typically phenomenological or quasi-empirical owing to the unavailability of predictive physical theories, but the availability of such relatively reliable data (compared with that of, say, ten years earlier) provides both a stimulus and seminal ideas for such theories.

Additional events included a precisely timed trip to view the Severn bore at three different stations. The bore was small but nevertheless exciting to those viewing it for the first time.

The format of this EUROMECH Colloquium, with a rather small number of participants with relatively homogeneous interests and commonly housed (as opposed to the separation that characterizes larger conferences with participants residing in various hotels) was highly successful. A summary of the conference is to be published in the *Journal of Fluid Mechanics*, following an increasingly popular procedure (as opposed to the publication of complete proceedings), which permits participants to discuss work only recently completed or still in progress and to choose appropriate journals for final publication. The organization was smooth and effective, for which the principal credit is due the chairman, D.H. Peregrine of the School of Mathematics, Univ. of Bristol. (John W. Miles, Scripps Institution of Oceanography, Univ. of California, San Diego, CA)

[The above article is a revised version of a Trip Report to ONR Code 438]

PHYSICAL SCIENCES

LASER VELOCITY MEASUREMENT RESEARCH HAS ITS REWARDS

Prince Philip recently presented five UK scientists with the 1977 MacRobert Award which included a cash stipend of £25,000 from the Council of Engineering Institutions (CEI). The award was for the development of the Malvern Correlator which when used with auxiliary laser equipment and a detector can be used for remotely measuring the velocity of particles. Four of the scientists, Dr. E.R. Pike, Dr. E. Jakeman, Dr. C.J. Oliver, and Mr. R. Jones are employed at the Royal Signals and Radar Establishment (RSRE) at Malvern and the fifth recipient, Mr. D.S. Trudgill, is Managing Director of Malvern Instruments, Ltd. Some of the uses to which the Correlator have been put include: Measurement of wind velocity, rate of flow of the blood in the retina, and airflow over an air foil.

The MacRobert Award, an annual award sometimes referred to as the "Nobel Prize for Engineering," was first given in 1969. The cash comes from a trust fund set up by the widow of Sir Alexander MacRobert, founder of the British India Corporation.

A visit was arranged for me by Pike to discuss his photon correlation work and to see other optical work in progress at RSRE. Pike cites the development of the Correlator as a good example of what can sometimes happen as a result of uncommitted research or in his terms "fiddling around." The concept came about in the late 1960's when Pike and Jakeman began to take into account the discreteness of light quanta in a theoretical treatment of correlation of detected light signals. A fast photomultiplier detector in conjunction with proper circuitry provides an electrical signal in the form of a string of standardized pulses when illuminated by light of low to moderate intensity. The electrical pulses produced represent actual photon detection events and can be easily processed by digital techniques. For example, time-dependent fluctuations in a scattered light signal produced by moving scatterers can be studied by forming the autocorrelation function of the pulses. This technique has become known as photon correlation. An exact method of performing this cor-

relation would consist of taking the digital counts detected in fixed sample times, T, which could be as short as a few tens of nanoseconds, and multipling them by counts received after a delay time, τ. The process would be repeated for many delay times and the results accumulated and averaged. However, this would be extremely expensive or impossible in practice for fast events because of electronic limitations. A theorem by Van Vleck and Middleton states that knowledge of the zero crossing points of a random ac signal are sufficient to determine most of the spectral information in it and that the power spectrum or autocorrelation function can be determined by using a binary signal having only two values, +1 and -1 with the same zero crossing points. Pike and Jakeman invented a modified version of this scheme in 1969 in which single-bit quantization is used with only a one or a zero being passed into a single shift register depending on whether the photon count exceeds the mean or not. The entire pulse train is "anded" into a memory along with the delayed single bits. Their theory shows that the end result is that the autocorrelation function for Gaussian signals is formed in the memory. This method is referred to as single clipping and is faster, simpler, and cheaper than analog or multi-bit processing and is a further improvement over the double-clipped method as the autocorrelation function is developed in the process. This technique is the basis of the Malvern Correlator.

One application of a photon correlator is in laser Doppler anemometry. Here two beams derived from a common laser are crossed at some point in space forming an interference fringe pattern. A particle travelling through the intersection region will produce scattered radiation which is modulated by the fringe pattern and from which the velocity can be determined. A more accurate theoretical treatment shows that the observed frequency is the difference in Doppler shifts for the scattered radiation from the two beams, $\Delta f = [2v \sin(\theta/2)]/\lambda$ where v is the particle velocity, θ is the convergence angle between the two beams, and λ is the laser wavelength.

Autocorrelation is one method of finding the Doppler-difference frequencies present in the scattered radiation, as the autocorrelation function will show a maximum whenever the delay time coincides with the period of a component of the signal. Other techniques used to recover the particle velocity information include the use of wave analyzers, frequency tracking filters and zero crossing counters. According to Pike, photon correlation when used digitally on detected photons rather than on zero crossings is inherently more accurate than the other methods since they require signal conditioning or filtering.

The Doppler-difference technique has been utilized for a number of other purposes. One of these is the measurement of subsonic and supersonic velocities and turbulence in flames and jets and motions in combustion chambers. Other applications include high-temperature air flow in the manufacture of cement, wind tunnel anemometry, velocity field measurements around helicopter rotors, and supersonic shock waves. The Doppler-difference technique can be used for wind measurement at moderate ranges up to about 100 m.

Remote wind measurements at longer distances are possible, but a different technique is required. Michael Vaughn described his work on a heterodyne method in which a single cw laser beam is focused at the desired position in space. Backscattered radiation is collected by a telescope and beat with a small fraction of the laser output at the surface of a square-law detector. Particles moving in the focal region produce Doppler-shifted radiation that results in a beat frequency appearing in the detector output. The operating range is varied by changing the focal point. The device, then, is a Doppler radar which measures the radial component of wind velocity. In the interests of eye safety a 10-μm CO_2 laser is used for this work.

An interesting property of this device is that the signal-to-noise is nearly independent of range. This is because the scattering volume increases with range and partially compensates for the inverse square-law dependence of signal on range. Ranges of 1 km are possible with this method.

The heterodyne anemometry technique has been pursued at RSRE for several years. According to Vaughn, the work is now moving from the research stage to application. A recent test of the device was carried out at the UK's Central Electricity Generating Board's DRAX Power Station where particle velocities in the plume were measured.

Another effort at RSRE is on laser rangefinders. Historically these devices have used pulsed solid-state crystal lasers such as CaF or Nd-YAG. RSRE are now developing an eye-safe Ho:YLF laser operating at a wavelength of 2 μm. This system is not yet fully engineered as a proper detector is not available. RSRE is well equipped to produce various crystal lasers and they have a large and well-equipped crystal-growing group which has been discussed in recent *ESN* articles by Klick *ESN* 31-12:494 and Lessoff and Kennedy *ESN* 32-8:273. (Vern N. Smiley)

INTERNATIONAL MEETING ON RADIO SCIENCE IN HELSINKI

The Union Radioscientifique Internationale (URSI) is one of the 18 worldwide scientific organizations that constitute the International Council of Scientific Unions (ICSU). It was formed in 1919 to promote international cooperation in radio science, and it now has 37 member countries, including both Germanys but only the smaller China. Twenty-one are European, and hence alternate General Assemblies of URSI are held in Europe. The most recent took place 31 July to 8 August 1978 in Otaniemi (6 km west of Helsinki), where the Helsinki University of Technology and several technical research organizations are located.

The General Assemblies are the occasions for business meetings of representatives of the 37 national URSI Committees and nine URSI Commissions as well as for scientific sessions devoted to topics chosen by the Commissions—usually singly but sometimes in interdisciplinary groupings. Between the triennial General Assemblies the Commissions organize numerous specialized national, regional, and international meetings, but the General Assemblies with their numerous parallel sessions cover a wide scope that includes the fields of all nine Commissions:

Commission A: Electromagnetic metrology, including radio standards and interactions beween electromagnetic radiation and biological systems.

Commission B: Electromagnetic theory and practice, including antennas and waveguides.

Commission C: Communication systems and system theory, including circuits; information theory and signal processing, including statistical fluctuation problems.

Commission D: Physical electronics and devices, including optical devices.

Commission E: The electromagnetic interference environment.

Commission F: Wave phenomena in non-ionized media, including radio meteorology, radio oceanography, and the remote sensing of non-ionized media.

Commission G: Propagation of radio waves in the ionosphere, including ionospheric communications and the remote sensing of ionized media.

Commission H: Waves in plasmas.

Commission J: Radio astronomy, including the remote sensing of celestial objects.

In some countries individual scientists are members of the national URSI Committee while in others, such as the US, the Committee includes national URSI Commissions, with which interested individuals may become affiliated. Such affiliation is not required, however, for attendance at URSI scientific conferences. URSI is supported by member governments and, through ICSU, by UNESCO, as well as by meeting registration fees, rather than by individual dues.

URSI does not itself carry out any research, but it does make recommendations relating to research requiring international cooperation and to standardization in measurements. URSI is particularly interested in reviewing recent progress, and at every General Assembly each member country presents written reports of its progress in each Commission's field during the preceding triennium. They are combined and are published by URSI (rue de Nieuwenhove 81, B-1180 Brussels, Belgium), the latest under the title "Review of Radio Science 1975-1977." Proceedings of the General Assembly as a whole are not published, but special 1979 issues of the journal *Radio Science* will carry the papers of some of the symposia that took place in conjunction with it.

As indicated in my report "Communication Engineering in Finland" (ONRL-R-4-77, 24 March 1977; also see *ESN* 31-2:43 and *ESN* 31-4:145), there is a fair amount of research and development in radio science going on in Finland. The program of the 1978 General Assembly included technical visits to some of the previously reported activities,

viz., the Technical Research Center of Finland, the precision 14-m radiotelescope (covering frequencies up to 100 GHz) at the Metsähovi Radio Research Station, the laser tracking system at the Satellite Geodetic Station in Kirkkonummi, and, of course, the Electrical Engineering Department of the Helsinki University of Technology (HUT). Other scientific visits covered the Nurmijärvi Geophysical Observatory 45 km northwest of Otaniemi and the Low-Temperature Physics Laboratory of HUT's Technical Physics Department, which is very impressively equipped as compared with the EE Department's Communication Laboratory. It is carrying on studies of superconducting quantum-interference devices (SQUIDs) fabricated at HUT. These devices involve flux quantization and Josephson tunneling.

On the 20-acre reservation at Nurmijärvi an ionospheric sounder, an auroral backscatter receiver, a seismic station, and several systems for recording magnetic-field variations were to be seen. Among the first three of the Observatory's buildings to be built in 1951 was the sauna, which was available for visitors' enjoyment during the tour. The lake just in front of it afforded a pleasant place to swim and cool off from the unusually hot and humid weather that afflicted southern Finland during the first half of the Assembly. The Observatory monitors meteorological conditions, including lightning and radioactivity—both natural and artificial. The pulsations of the earth's magnetic field, with a period of the order of a second, that are recorded at Nurmijärvi are analyzed mainly at the University of Alaska but also at Oulu University in central Finland near the top of the Gulf of Bothnia.

In addition to nearly a hundred regular sessions, the 1978 General Assembly included five symposia and two workshops. Their topics were Time and Frequency (dealing with metrology and the dissemination of standards), Biological Effects of Electromagnetic Waves (on which J.B. Bateman is writing a separate article), Optical Communication (especially via glass fibers), Radio Waves and the Ionosphere, Wave Instabilities in Plasmas, Wave Analysis, and Large Digital Correlators.

There was also a special session devoted to the conferring of awards, at which the Balthasar van der Pol URSI Gold Medal was given to James R. Wait (US Department of Commerce, Boulder, CO) for his work on the radiation and transmission of electromagnetic waves in the earth; the J. Howard Dellinger URSI Gold Medal went to Donald A. Gurnett (Univ. of Iowa) for his research on magnetospheric physics, including his studies of the kilometric (200-to-500-Hz) radiation from the earth (totaling 10^9 W generated by the aurora, which does not, however, reach the earth's surface), and its implications for radio propagation; and the Royal Society of London's Appleton Prize was awarded to Peter M. Banks (Physics Dep't, Univ. of Utah) for his research on the plasma flow (exceeding 7 km/sec) from the ionosphere to the magnetosphere. This "polar wind" is both subsonic and supersonic. The three men responded with brief talks discussing their work and acknowledging the contributions of others to it. There were also tributes to the memory of Samuel Silver (1915-1976) (Univ. of Calif., Berkeley), who had been president of URSI from 1966 to 1969 and who in 1973 had become a permanent honorary president of URSI. Although his research dealt mainly with various areas of physics, he is best known for volume 12 of the MIT Radiation Laboratory series, *Microwave Antenna Theory and Design*.

In attending the General Assembly I concentrated on sessions of Commissions C and E while taking advantage of most of the technical tours. Not all of the sessions occurred as planned, however. For example, one on "Advances in Information Theory" that was to have been organized by R. Dobrushin of the Institute for Problems of Information Transmission (IPIT), Moscow, did not take place, but Dobrushin was not present to explain why. The session that L.A. Vainstein had organized on "Electromagnetics in the USSR" did take place but without Vainstein and four of the five speakers he had lined up. The latter, I heard, were replaced by others who succeeded in getting to Helsinki as tourists but were nonetheless able to present suitable talks. There were individuals from other countries, too, who failed to meet their commitments; this is not purely a Soviet problem. V.I. Siforov, Director of the IPIT, who has often represented the USSR at URSI meetings and elsewhere, was among the Russians who attended. He announced that in June 1979 his country will hold an International Symposium on Information Theory in Tblisi—apparently just before the one organized by the IEEE Information Theory Group 25-29 June in Grignano near Trieste, Italy.

Among the sessions I enjoyed was one on new approaches in broadcasting, which included papers on teletext in the UK (*ESN* 31-2:72), the proposed UK Carfax traffic-information network, quadraphonic FM developments in Hungary, and a new approach to an audio-bandwidth broadcasting satellite for community reception in the UHF TV band. Ernest K. Smith (Jet Propulsion Laboratory, Pasadena) discussed this 3.4-kHz-bandwidth satellite system, which might provide an audio return link for rural students in a TV class. It would make use of the 2-MHz-wide, 40-dB-deep trough 1 to 3 MHz above the luminance carrier of an NTSC (American) color-TV signal. It could, Smith concluded, accommodate 42 FM audio channels, each 47 kHz wide.

Prof. P. Ferenczy (Tech. Univ. of Budapest) reported that Hungarian Radio (Budapest) has been experimenting with quadraphonic FM broadcasting since 1969, but the lack of an accepted international standard technique has delayed implementation. The emphasis, he noted, has been on plays rather than music, and a new approach to the selection, writing, and production of plays will be needed in order to exploit the possibilities of quadraphony without distracting the audience.

In regard to teletext, J.P. Chambers (BBC Research Dep't, Kingswood Warren, Tadworth, Surrey, UK) observed that positive ghosts with short delays that do not adversely affect the TV picture can be very detrimental to teletext reception while a 9-dB margin remains before Gaussian noise causes serious errors.

C. Bell (BBC Research Dep't) reported that members of the European Broadcasting Union have since 1971 been studying methods for providing traffic information on a regional basis to car drivers. The BBC proposes an approach, called Carfax, involving a single dedicated AM audio channel at about 531 kHz and a network of low-power transmitters that take turns sending bulletins for their local areas, each preceded by an FM header which, if received satisfactorily, will activate the receiver. Each transmitter will radiate a jamming waveform during the header intervals preceding bulletins for neighboring areas. These, if stronger than the neighboring area's header, will, by virtue of the FM capture effect, prevent turning on the receiver for the weaker transmitter's bulletin. Thus, the receiver will respond only to the nearest transmitter, whose bulletins relate to the local area. Tests will begin in November 1978 with five transmitters in the London area. An embellishment is being studied which would use different header codes for bulletins of interest to different types of vehicles or bulletins in different languages.

Another interesting session I managed to attend dealt with speech processing (see also *ESN* 31-10:402 and 32-8:262). Prof. Gunnar Fant (Dep't of Speech Communication, Royal Institute of Technology, Stockholm) discussed the various approaches to speech synthesis, whose common aim is to convey to the listener the desired effect through sounds generated from a minimal number of information bits. These sounds, Fant noted, thus become a stylized approximation to the human voice with analogies to art, and what is acceptable depends upon changing, subjective criteria.

The speech synthesis can, as in the case of the vocoder, use a finite-time spectral representation, or, as in the case of linear predictive coding, it can rely on a model of the vocal tract. A third approach, synthesis by rule, resembles the reading of a phonetically spelled text. It is useful for spoken computer output and for helping the blind to read. These approaches contribute insights into linguistics and phonetics as well as into the speech-production process and hearing.

Dr. John Makhoul (Bolt Beranek and Newman, Cambridge, MA) reviewed the various methods that are in use for low-data-rate speech transmission and indicated that, by means of sufficiently complex processing, 2400 or even 1600 bits/sec will suffice for producing a quality equal to that of the original voice. He showed by means of tape recordings that the speech can be speeded up by as much as 50% without affecting the identifiability of the speaker, and by changing the frequency of the first formant its pitch can be altered so that it almost sings tunes while leaving the voice still recognizable.

Speech recognition was the topic of C. Gueguen (Ecole Normale Supérieure de Télécommunication, France). While isolated words from a single speaker can be electronically recognized, continuous speech must be segmented into words before isolated-word recognition techniques can be applied. The segmentation is made difficult by the presence

of weak fricatives and stop consonants, and it is thus necessary to use dictionary, grammatical, semantic, and pragmatic information to combine some of the segments and sort out words. Because of the ambiguities of the sounds, two passes are needed—the first to build up a lattice of possible interpretations and the second to reduce it, if possible, to a single choice. In the case of a plurality of speakers, the first step is to recognize the speaker and then to attempt to match observed speech parameters to the templates on file for him. This is the aspect of speech processing whose development will take by far the longest, but it will be aided by the findings of research on speech synthesis and narrowband transmission.

There were other sessions that sounded fascinating which I did not get to. Among these were those on electromagnetic waves and the gravitational field, nonlinear effects excited in the ionosphere by radio waves, the physics of nonthermal radioastronomical sources, electromagnetic theory in geophysical exploration, and the search for extraterrestrial intelligence.

Professors Martti Tiuri and Seppo J. Halme of the Helsinki University of Technology and the others who helped to organize the General Assembly are to be congratulated for the excellent general arrangements. The 800 who attended are indebted to them and to the many others who arranged the individual sessions and the symposia. The next URSI General Assembly will take place in 1981; the URSI Council will shortly be deciding between the two proposed sites—Washington and New Delhi. (Nelson M. Blachman)

ELECTRON MICROSCOPY IS STILL WET AT IMPERIAL

One of the better known research activities at the Metallurgy and Materials Science Department of the Imperial College of Science and Technology, Univ. of London, is the use of their AEI EM7, high-voltage 1-MeV transmission electron microscopye(HVTEM) to perform *in situ* experiments of various metallurgical phenomena. The major reason why such experiments are possible is that the large available working volume around the specimen permits a variety of complex and specialized specimen chambers to be inserted.

Much of the pioneering design and implementation work in this area has been carried out by P.R. Swann who, until he recently left for the US to go into private business, was Central Electricity Generating Board Professor of Corrosion Science at Imperial. His development work over a period of years led to the construction of stages which could be isolated from the microscope environment in order to permit the safe introduction of gases or liquids for studies of the corrosion and oxidation behavior of metals and ceramics. Through a series of iterative designs, a final chamber emerged that provided great experimental flexibility. Its success is attested to by the fact that a US company, of which Swann is a principal, has constructed a large proportion of the environmental chambers used on HVTEMs in the US and abroad.

The specimen chamber is constructed of a highly dense uranium alloy to ensure adequate protection from x-rays. A side entry specimen configuration is used to incorporate more easily such services as tilting, heating, cooling, etc. For high temperature studies a good chamber vacuum is essential. This is achieved by differentially pumping all sliding seals in the region of the specimen, creating a local vacuum of better than 10^{-7} Torr. Heating is achieved by a combination of electrical resistance and radiation shields which when properly used can produce a temperature stability of the order of only ±1°C over a quite sizable temperature range.

A unique application is the introduction of moist or dry gases to the chamber for *in situ* corrosion and oxidation experiments. These processes can be continually monitored to allow, for example, measurements of their kinetics. In addition, the high magnification and resolution of their HVTEM and the capability of using thicker specimens that can be "electron-transparent" at 1 MeV combine to permit detailed mechanistic information to be obtained, and on materials thick enough to mirror bulk behavior successfully. This is important in oxidation studies since bulk internal stresses, so sensitive to thickness, can have a strong effect on the subsequent morphology and perfection of the surface oxide film.

The HVTEM group at Imperial have also been pioneers in *in situ* investigations of water-vapor-induced stress-corrosion-cracking in aluminum alloys, particularly the aluminum-zinc-magnesium-copper alloys used extensively for aircraft structural and skin components. These alloys are particularly susceptible to cracking especially when they are heat treated to maximum strength. Because of this, such alloys (most notably the commercial designation 7075) are invariably used in a lower strength condition which is obtained by over-aging the alloy during thermal treatment. This need to use the alloy in a lower-strength condition leads to a design weight penalty and a concomitant loss in payload. In order to develop better, i.e., stronger, more stress corrosion resistant alloys, the mechanism of cracking and in particular the role of grain boundary and lattice precipitates in the cracking process must be known. These precipitates have been shown by many investigators to be directly involved in cracking, particularly at the initiation stage. An elucidation of such effects is the ultimate goal of Imperial's research program.

Specifically, bend specimens of a high purity Al-Zn-Mg alloy are exposed to moisture at modest temperatures either in the environmental cell or by pre-exposure in an external autoclave at a temperature 120°C and a pressure of 2 bars; with the latter procedure they are then subsequently examined in the HVTEM. The most important finding to date is that the observed loss of ductility is correlated with the presence of large amounts of hydrogen at or in the vicinity of grain boundaries. Long time exposure, in fact, actually leads to the formation of hydrogen gas bubbles (as confirmed by mass spectrographic analysis of the gas evolved during fracture). Maximum embrittlement is found for exposure times much less than that needed for bubble formation, suggesting that it is the hydrogen in solid solution at the grain boundaries that is the most potent promoter of embrittlement. This suggests the possibility, already partially confirmed by experiment, that if hydrogen can be induced to precipitate as fine gas bubbles thereby decreasing its chemical activity in solid solution, the alloy's susceptibility should decrease. The use of a particular distribution, type, and size of precipitates, which could act as preferential traps for hydrogen and provide nucleating sites for bubble formation, could be an important remedial design procedure, and studies along these lines are ongoing both at Imperial and at several research centers in the US and Europe.

The presence and maximum exploitation of a state-of-the-art HVTEM is critical to the success of studies using this experimental approach. As discussed previously, the specialized chamber and thick specimen (in low atomic number aluminum this can be as great as several tenths of a millimeter) provide ideal study conditions. This is particularly true for experiments in which the presence of hydrogen is to be detected and its effects monitored. The thick foil prevents excessive loss of hydrogen to the external surfaces, while the presence of large electron-transparent areas permit the orientation studies necessary to unequivocally establish the presence of hydrogen gas bubbles. Further, a high localized flux of hydrogen can be generated, allowing the maximal effects of this solute on mechanical properties to be assessed. This flux is obtained by interaction of the incident electrons with the defect structure of a hydrated magnesium oxide or a hydroxide, particularly at those regions where the grain boundary intersects the surface.

The departure of Swann who not only spearheaded the group's research program, but who was also very adept at competing with the other major HVTEM centers (e.g., Oxford, Cambridge, Birmingham) for long-range support from the Science Research Council (SRC), clouds the long-term viability of the microscopy effort. Although he is yet to be replaced, the fortunes of the group have not suffered markedly. Under the leadership of Drs. H.M. Flower and P. Butler they have obtained a three-year SRC grant for support for the microscope facilities (one year less than they requested) and have had their research contract from the US Army Research and Standardization Group (Europe) extended. Also, Swann continues to maintain active contact with the ongoing research. Clearly there is a bit of a wait-and-see attitude, with interest centered on who, if anyone, will be Swann's successor. However, at least for the present, much of the electron microscopy is still all wet at Imperial. (I.M. Bernstein)

MICRO 78: BE IT RESOLVED...?

The Royal Microscopy Society's biennial International Symposia and Exhibition, dubbed MICRO 78, was held in London, 10-14 July, with about 600 attendees, mostly British. When there are typically a dozen major microscopy meetings each year worldwide, one could ask whether MICRO 78 was just another forum to show off splendid photomicrographs. Certainly overall there is much redundancy in these conferences, no single meeting dominates, and the program never completely covers the worldwide state-of-the-art. Nevertheless, they reflect the tremendous activity and interest in microscopy, and the RMS meeting is one of the superior ones. One reason is that significant electron microscope developments continue to be centered in Britain, see for example Bernstein (*ESN* 32-2:65). Also, the RMS is a well-staffed and well-funded society which devotes full time to the field, sponsoring numerous specialist meetings and courses each year. Its sections (Electron Microscopy, Materials, Histochemistry, and Cytochemistry) serve two basic application areas, the life and materials sciences, and the format for the RMS meeting includes a comprehensive Trade Exhibition and a set of concurrent Scientific Symposia organized through the various sections. Full conference proceedings are not published, but many papers eventually appear in the Society's *Journal of Microscopy*.

When compared to other meetings the biennial RMS meeting is notable in fostering a harmonious, mutually productive relationship between materials and life scientists. This is accomplished through the efforts of invited speakers who cover designated topics, represent themselves as microscopists rather than specialists in a given application area, and keep their presentations technique-oriented. For the materials scientist, interest at MICRO 78 was in the various techniques of what may be generally termed high resolution electron microscopy (HREM). Symposia entitled "Review of Technical Advances in Electron Microscopy" and "High Voltage Electron Microscopy" were notably eclectic in nature, with contributions from both the materials and life sciences communities, and although separated in the program, were quite complementary; also, linked symposia on "Microscopy of Voids" and "Microscopy of Interfaces," although largely concerned with physical metallurgy, were based mainly on data resulting from high resolution studies.

MICRO 78 reemphasized the wide range of sophisticated electron microscopes being used to study atomic arrangements, chemical composition, surface structure, etc. The design of the conventional transmission electron microscope (CTEM) is changing radically under the influence of newer types such as the scanning transmission electron microsocpe (STEM) and the high voltage electron microscope (HVEM). Also, new techniques such as energy loss analysis and convergent beam electron diffraction are being used more and more. These developments were reviewed by several authors, and since the presentations tended to overlap, in what follows I will limit myself to a summary of the discussions in various topic areas rather than attempt a paper by paper coverage. While some of the points mentioned may not be brand new revelations to followers of the EM scene, at least this was the most recent meeting at which they were reviewed.

HREM (High Resolution Electron Microscopy): One reason for the increasingly harmonious and mutually beneficial relationship between microscopists of differing persuasions may be that we are now at the point where both materials and life scientists are able to resolve the smallest structural units of interest in their particular samples (atoms and molecules, respectively). Therefore many presentations "focused" on high resolution results. Actually, it would be more appropriate to say "underfocused," reflecting the operational technique employed to enhance the contrast which is essential for realizing theoretical resolution. HREM was discussed in review presentations by T. Mulvey (Univ. of Aston in Birmingham, UK), D.L. Misell (National Institute for Medical Research, Mill Hill, UK), R.M. Glaeser (Division of Medical Physics, Univ. of California, Berkeley, CA), G. Thomas (Dept. of Materials Science, Univ. of California, Berkeley, CA) and V.E. Coslett (Cavendish Lab., Univ. of Cambridge, UK). Misell pointed out the areas in which there are significant differences between various EM configurations, (CTEM, STEM, and HVEM), including: 1) resolution and fidelity of the image; 2) the effect of inelastic electron scattering on image contrast and resolution, including the effect of chromatic

aberration; 3) image contrast in dark field and bright field; 4) comparison of phase and scattering contrast; 5) radiation damage and image recording techniques available to minimize it; 6) capability for photographic and electronic image recording; 7) capability for microanalysis, electron diffraction, and energy loss electron analysis. These points of distinction were not addressed completely by any one speaker, but they were considered in part by many and some of the main conclusions appear below.

Misell pointed out that the definition of "high resolution" is quite different for biologists and metallurgists, and suggested that rather than state resolution in terms of an absolute distance, it is more significant to consider that high resolution has been obtained when it is possible to extract all important structural information from the image. Also "fidelity" is important, referring to the degree to which features of an image actually correspond to the specimen structure. For example, in CTEM, image fidelity is conventionally low because of diffraction contrast features in the image. Several speakers emphasized the need for special care in operation and image interpretation to ensure that image contrast under high resolution conditions is correctly identified with the real structure. One of the basic techniques in this regard is to record images at a series of underfocus values.

In metallurgical applications, Thomas described the use of high resolution lattice imaging and laser optical microdiffraction, together with conventional microdiffraction methods. Examples presented included current research on spinodal and martensitic alloys and studies of grain boundary characterization in ceramic alloys (e.g., Si_3N_4). His examples illustrated a useful aspect of lattice imaging, namely the possibility of obtaining relatively good fidelity in the CTEM.

Glaeser and others considered the subject of crystal structure identification via lattice imaging, with and without prior knowledge of the structure. Lattice imaging has also opened a new study area in microchemistry. Mulvey offered an example involving the study (at 100 kV) of the penetration of atomic species such as oxygen into oxides.

HVEM (High Voltage Electron Microscopy): There are currently about 40 HVEM's in the world with greater than 600-kV accelerating voltage, seven being in the UK. They are being used mostly for research on inorganic crystalline materials. However, Thomas reviewed the advantages of HVEM that enable the materials scientist to extend studies into new fields, such as ceramics, since the higher penetration of HVEM overcomes the difficulty of preparing thin sections. In biological applications, advantages of HVEM are only slowly being exploited. Here increased penetration allows the use of environmental cells to examine samples in a hydrated condition or gaseous atmosphere. Stereo examination is also helpful to sort out complex three-dimensional structures in many biological specimens. Another advantage is a reduction in radiation damage due to ionization, which should aid in the study of radiation damage in biological material and macromolecules. The ejection of individual atoms above a threshold voltage, on the other hand, allows direct observation of radiation damage in metals. Additionally, the ability to observe thicker specimens with HVEM provides a better approximation of the bulk material, therefore, various sorts of realistic *in situ* experiments are possible. H.M. Flower and E.P. Butter (Imperial College of Science & Technology, Univ. of London, UK) gave examples of hot-stage experiments to study microstructural changes caused by various types of phase transformation over an interval of time and described gas reaction cells used to monitor oxidation and reduction reactions directly.

Progress toward the higher resolution that high voltage should (in principle) provide has been hindered by practical problems of both mechanical and electrical stability. Thomas pointed out that attempts to achieve the ultimate resolution, viz, that at the atomic level, must await specially designed high voltage microscopes. In this regard there are currently only two HVEM's in the world which have promise, on the basis of their design, of obtaining theoretical resolution for their particular accelerating voltage, namely the new 600-kV machine at the Cavendish Laboratory at Cambridge, and that at Kyoto, Japan. At this conference, there were no representatives of the Japanese group, but W.C. Nixon (Cambridge Univ., UK) re-

ported on the progress of the Cambridge HVEM, first operated in September 1977; present point-to-point resolution is better than 3 Å, with no indication that any limit has been reached. The special design features of this Cambridge microscope have been reported earlier by Bernstein (see *ESN* 32-2:65).

STEM (Scanning Transmission Electron Microscopy): In STEM, the image is built by scanning a small diameter beam of electrons over the specimen and continuously monitoring the varying intensity of transmitted electrons to modulate a cathode-ray tube display, with the resolution obtained approximately the beam diameter. Electron microscopes specifically designed for STEM operation (as distinguished from STEM attachments to CTEM's) are now available commercially from at least three manufacturers: VG Microscopes, Kratos/AEI Scientific Instruments, and Siemens. It is interesting to note, however, that a purpose-built STEM was not operating at the MICRO 78 Exhibition.

Contributions at MICRO 78 illustrated that STEM has several notable advantages: 1) its small probe is useful for small-volume microanalysis; 2) the image has no contribution from phase contrast, only scattering contrast; 3) as there are no lenses after the specimen, there is no chromatic aberration due to scattering in the specimen, so it is more useful for thicker specimens than CTEM; 4) it is possible to select and display a wide variety of signals. An example of this last point is the so-called "Z-contrast" technique pioneered by Crewe and his coworkers to produce images of single heavy atoms on carbon substrates.

In STEM it is possible to detect, by means of an annular ("dark-field") detector, all elastically scattered electrons to form an incoherent dark-field image. This mode of operation can be made 100% efficient as compared to typical CTEM dark-field efficiencies of between 1 and 10%. Phase contrast images can be obtained in the STEM by using a small collector aperture; while this is not an efficient mode of operation, images equivalent to those in CTEM can be obtained. Also, a simple electron spectrometer can be used to select a range of electron energies to form an image; thus the STEM can be used directly to demonstrate the presence of phase contrast in inelastic images. For biological applications, STEM operation at high resolution in dark field is particularly useful. First, the dark-field image is free of phase contrast which often makes interpretation difficult; second, the use of the efficient STEM technique enables the control and minimization of specimen irradiation.

STEM is more easily developed as an analytical tool than is the CTEM. For example, the technique of electron energy loss spectroscopy (EELS) may be used to give light element analysis, and x-ray elemental analysis can be obtained for selected areas less than 10 nm in diameter; microdiffraction is also possible, of course. STEM image display has certain advantages over CTEM; for example, electronic amplification produces a bright screen at all magnifications, making it easier to focus, etc. Further, the availability of a line scan mode can be used to develop various types of image profiles. A possible disadvantage of STEM is that one has to wait for the image to be scanned, whereas the whole image is produced at once in CTEM.

It is not yet possible to assess the relative merits of CTEM and STEM completely, since neither has reached technical perfection. However, it is likely that the diversity of instrumental designs will continue in future, as it is difficult to optimize all aspects of electron microscope design in a single machine. An interesting instrumental development discussed at the Conference is the use of microprocessors to determine optimum lens settings, thus ridding the operator of the task of balancing settings and allowing more complex microscope designs (e.g., more lenses) without operational penalty.

Convergent-beam electron diffraction: This technique differs from conventional electron diffraction in the TEM in that a focused beam of electrons is imposed on the specimen, with convergence of the beam controlled so that divergent cones of diffracted electrons are imaged. This method, known almost since the discovery of electron diffraction, has been used very little until recently. One reason for this is that standard electron microscopes required modification to achieve a suitable convergence angle; also, specimen contamination (breakdown and deposition of organic impurities in the microscope column) with a converged beam tends to be severe. These problems have now been

largely overcome. Contemporary machines usually have or can be fitted with objective lens-pole pieces suitable for use in STEM, and this configuration is ideally suited to the convergent beam technique. The contamination problem can be overcome operationally or with better vacuum conditions.

Mulvey described the additional information to be obtained from convergent beam electron diffraction patterns. Such patterns have unusually large spots, with a complex pattern of intensity within each (unless the specimen is very thin, in which case no contrast is seen). The structure can be interpreted to give considerable crystallographic information; for example, it provides a simple and accurate method of determining the point and space groups of the crystal. Also, the "holz lines" within the discs can be used to determine precisely the lattice parameter or small lattice strains.

EELS (Electron Energy-Loss Spectroscopy): EELS is based on the study of inelastic scattering events as electrons pass through a sample. For chemical analysis, the most important inelastic events are the ionizations of inner atomic shells, since these cause discontinuities (absorption edges) in the EEL spectrum at characteristic energies. The amplitude of the edge depends on the ionization cross section of the atom and the collection efficiency of the spectrometer device, and for light elements ($3 \leq Z \leq 15$) both these parameters are high. Therefore, EELS comprises an excellent complementary analytical technique to energy-dispersive x-ray spectroscopy (EDXS) for joint application to electron microscopes. STEM, with a high brightness electron gun, is ideal for EELS. In addition, from the fine structure of the spectrum, EELS can give information to highly localized analysis about chemical bonding in the immediate vicinity of the excited atom.

Image processing: For materials scientists such as myself, who have been given the idea that biological applications of electron microscopy are inherently inferior, and don't make full use of the capabilities of the instrument, it was interesting to learn of some valuable new techniques that are being evolved in the life sciences, particularly in image processing. A problem is that organic materials are quite susceptible to irradiation damage from high-energy electrons, with significant damage typically realized after a dose of about 10 electrons/nm^2. Electron micrographic exposures typically involve about 100 times this value. This imposes severe limitations on the meaningful resolution obtainable, since if the dose is kept low to avoid damage, the signal-to-noise ratio of the image will be low, and it may not be possible to observe fine detail, particularly if they have low contrast. Glaeser explained that this problem can be overcome by the use of spatial averaging for specimens that possess a sufficient degree of spatial redundancy, and that recent work has shown this can be done even with noncrystalline materials so long as the individual particles are all oriented with a common axis parallel to the electron beam. In this method image noise is reduced by Fourier transforming the image to obtain the diffraction pattern (wherein the noise is effectively filtered), then reprocessing by inverse Fourier transformation back to a noise-free image. A less sophisticated method described by Glaeser is the use of low specimen temperatures, where the tolerable exposure can be as great as a factor of 5 to 10 relative to the no-damage exposure at room temperature. Another aspect of this problem is that the loss of crystalline structure in organics occurs at a rate 2 to 4 times more slowly at 1 MeV than at 1 keV. Glaeser believes that with further improvements image resolution of 0.35 nm or better with crystalline biological materials will be possible.

Optical Diffractometry: The use of optical diffractometry in tandem with TEM images was widely discussed. There is a long list of dividends to be gained by use of this method, including the ability to obtain better lattice spacings measurements than is possible directly from the lattice image. Optical diffractometers are a relatively inexpensive addition to the electron microscope arsenal, and can be used not only to obtain information from the image but also to assess performance. For example, astigmatism, aperture contamination, drift, etc., can be evaluated, often quantitatively.

Symposia on Microscopy of Voids and Interfaces: A whole symposium on the "microscopy of voids" may seem like a festival to determine the taste of donut holes. In fact, the linked symposia on microscopy of voids and

interfaces were of great interest in terms of both general microscopic techniques and physical metallurgical principles. Several authors addressed special microscope techniques that must be used for examining voids, whether produced by irradiation, deformation, sintering, or otherwise. Voids span a range of sizes, and W.M. Stobbs (Cambridge Univ., UK) pointed out that techniques vary with the situation, from the use of structure factor contrast for relatively large pores, through Fresnel contrast for intermediate pores (20 nm to 0.4 nm), to elastic side-band imaging and atomic resolution techniques for pores with sizes less than about 0.6 nm.

One application for void imaging described by M.R. Hayns and R. Bullough (AERE Harwell, UK) is in the study of radiation damage in alloys. Here it is of particular interest to elucidate the physics of the origin and evolution of void distributions, and this requires the attainment of ultimate resolution. Another case, described by M.J. Makin (AERE Harwell, UK), was the application of the HVEM both to produce and study voids in materials of moderate atomic weight, relevant to the void swelling problem in nuclear structural materials. A series of papers considered the physical metallurgy of voids in sintered materials, and another group considered the role of voids in plastic deformation processes.

In toto, MICRO 78 gave a complete, eclectic, and vigorous coverage to all aspects of high resolution electron microscopy. It is obvious from the symposia that electron microscopy techniques are becoming more sophisticated, and from the Trade Exhibition that the associated equipment is becoming more elaborate, specialized, and (of course) expensive. (Jeff Perkins)

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PSYCHOLOGICAL SCIENCES

THE TRAINING OF LEADERSHIP

Are good leaders of an organization effective because of what they have learned about leadership principles in organizational contexts, or are they effective because of the ability and personality characteristics that they bring to the leadership role in the first place? There was a leadership symposium at the 30 July-5 August 1978 meeting of the International Association of Applied Psychology at Munich, and the answer to the question proved to be on the side of training—leaders are made, mostly, not born. No one would deny that a favorable configuration of ingrained capabilities could benefit a leader, but there is much that can be learned. The symposium was dominated by F.E. Fiedler (Univ. of Washington, Seattle), and R.J. House (Univ. of Toronto, Toronto). Fiedler's position was the strongest and most explicit, which is not surprising because he has been refining his ideas for 25 years on a basis of continued research.

There are several elements of Fiedler's theory that must be appreciated before his position on leadership training can be understood. The first is his tool for measuring ingrained leadership style, called the LPC (Least Preferred Co-worker) Scale. The LPC is an 18-item rating scale by which a leader rates the fellow worker whom he likes the least. From this scale a leader will be classified as a High LPC Leader or a Low LPC Leader. High LPC Leaders get their major satisfaction from good interpersonal relations. Their self-esteem depends on how other people regard them. Low LPC Leaders care less of what others think about them. They derive satisfaction from getting the job done, even at the cost of good relations with followers.

The second element to understand is that there are three components that determine control and influence in a leadership situation:

1. Leader-member relations. This is the degree to which group members support the leader, and it is measured by a Leader-member Relations Scale.
2. Task Structure. This is the degree to which the task specifies goals and procedures, and it is measured by a Task Structure Rating Scale.
3. Position Power. This is the degree to which the position gives the leader authority. It is measured by a Position Power Rating Scale.

These three scales combine to give a Situational Control Scale, from which the leader can estimate his control of the situation. A high control situation is predictable and structured, with everyone knowing what they are supposed to do. The leader has control and influence. An engineer in charge of a bridge construction job is in a high control situation. A low control situation is unstructured, with procedures and methods unclear. The leader has little or no power to get things done. The director of a laboratory doing basic research is in a low control situation. A moderate control situation is a mixed case, as the label implies. Fielder has hypothesized how Low LPC Leaders and High LPC Leaders operate with different effectiveness in each of these situations. For example, a Low LPC Leader is in his element with a high control situation, but a High LPC Leader, with his need for group support, would allow his feelings to get in the way of getting the job done in a no-nonsense way.

It might seem that the solution is selecting the right leader for the situation. Fiedler would not deny the advantages of selection, but he sees neither the situation nor the leader as static, where the situation is defined and the leader selected for it. Rather, he believes that the leader can be trained to manipulate the situation and bring it into alignment with his leadership style (as defined by the LPC Scale). A leader may naturally have a match with the situation but, if not, he can change the situation and move it closer to a match.

The leadership situation is changed by engineering the three components that determine control and influence, listed above. The leader can modify the leader-member relations by becoming more or less accessible, by having an advisory committee or not, etc. Task structure can be modified by asking the superior to assign unstructured situations or not, by volunteering for unstructured situations or not, etc. Position power can be manipulated by fully using the power available, diluting power by allowing group members to participate in decision-making, etc. Fiedler contends that these leadership skills can be learned in as little as 4-6 hours of study of a programmed text that he and his associates have developed (Fiedler, F.E., Chemers, M.M., and Mahar, L. *Improving leadership effectiveness: The leader match concept*. New York: Wiley, 1977, Revised Edition).

Fiedler presented validation data for the programmed text approach from 12 studies, 5 of civilian organizations and 7 in military settings. The paradigm of each study was an experimental group of leaders who received the programmed text and a control group that did not. Evaluation of the subjects was by ratings of efficiency in their jobs. In all 12 studies the experimental groups were superior to their respective control groups. This is encouraging support for theory, although 4-6 hours reading of a programmed text is unstructured study, and there is no way of knowing the parts of the theory that a subject learned or the parts that were used when they were learned. The validation, therefore, is global; it is practically useful, but the verification of theoretical details that the aficionados of leadership require is lacking. So far, Fiedler has travelled a greater distance in applied psychology than in basic theory. A congress of applied psychologists did not find this accomplishment unsatisfying.

House has a charismatic theory of leadership. A charismatic leader enhances the ego and self-esteem of his followers. He asks high performance of his followers, and these expectations tend to be fulfilled if the leader has had past success. He knows what his followers need, defines paths to the goals, and he arranges jobs and rewards so that the followers attain the goals. Martin Luther King, Ghandi, Hitler, and Alexander the Great were charismatic leaders.

House said that empirical findings in support of the charismatic theory of leadership are mixed. He reported one of his studies which separated charismatic and non-charismatic leaders, and the charismatic leaders were found to be mainly emotional in their appeal. Non-charismatic leaders appealed to reason and logic, by contrast. House believes that eventually we might train leaders to be charismatic in certain situations, once their characteristics are better understood.

The problem with the charismatic theory is not that it is a theory as old as mankind, or that it asks us to believe that the strains of Alexander the Great run in us all, but that it

deals with only one type of leader and does not specify leader-situation interactions. Could a charismatic leader effectively direct the building of a bridge? A basic research laboratory? Whatever the empirical fate of the details of Fiedler's theory, there is a richness about it in specifying different types of leaders, the situations in which they must operate, and what they must do to be effective in each. (Jack A. Adams)

BUY A SHARE OF THE CASINO IF YOU WANT TO MAKE MONEY AT GAMBLING

There were 2000 psychologists from 70 countries at the 30 July-5 August 1978 meeting of the International Association of Applied Psychology at Munich, and there were programs on everything from cross-cultural behavior to physiological psychology. One of the many symposia was on gambling behavior, and of particular interest were papers on the surreptitious on-site recording of gambling at casinos in South Lake Tahoe, Nevada, by N.A. Bond, Jr. (Dept. of Psychology, California State Univ., Sacramento), and the analysis of fallacies by W.F. Gabrielli, Jr. (Social Science Research Institute, Univ. of So. California) that keep gambler's from viewing the characteristics of probabilistic games as they really are. The human would give up gambling if he were a rational statistician because he would know that there is no long-run chance of winning (blackjack is an exception), and even in the short-run he is at a disadvantage because of his limited betting capital. Instead he is bedeviled by irrationalities that cause him to persist in gambling.

Bond emphasized blackjack in his research, and rightly so because it is the only casino gambling game in which the player has a chance of winning a small amount if he plays a rational game with perfect memory. The player in blackjack pits himself against the house dealer, who plays a fixed strategy. He bets that the cards he receives from the dealer sum to 21 or less, and that they sum to more than the cards that the dealer gives to himself. There is a bit more to it than this, but not much more. Bond calculated that with a $1.00 bet each time, a rational player can make $1.50 every 1000 plays. These are small winnings, but the less than rational human doesn't even do that well. In his study of 53 players and 940 games, losses were 6%. Bond is a skillful blackjack player so he could collect data accurately and infer about it, and he made observations about the strategies that players used. There was no evidence in 84% of the games that memory was being used. Nor was there understanding of the principle that a few large bets can get you more than many small, cautious bets. Bond estimates the probability of increasing $100 to $200 via many small bets to be $(6.06)(10^{-6})$, but the probability of increasing $100 to $1000 via a few large bets is approximately 0.08. The typical player makes small bets.

The players' understanding of slot machines was equally poor. The machines that Bond studied were set to absorb 25 cents on the average for every dollar played. Another way of looking at the player's dismal chances of winning is that the probability of winning more than 500 coins with 500 played is 0.0001. Interviews with the players found them believing this probability to be 0.10-0.20, and a main reason was that they felt they were in control of the machine. It was common for them to believe that a machine can be controlled by the handle (it cannot), or that it can be "hot" (it is a random generator that is neither "hot" nor "cold"). The player emerged no wiser in Bond's studies of Keno (a Bingo-like game) and pari-mutual horse racing.

Gabrielli's thesis was that the human mind is filled with fallacies about the probabilistic situations that are gambling, and he had a long list that research has established. Among them were that low probability events of high payoff are incorrectly perceived, the independence of events is unappreciated, and the player expects an event to occur less or more frequently depending upon the occurrences in the event's recent past history, there is an over-emphasis on the relatively long runs that can sometimes occur when only a small sampling of events is taken, sequences of events are believed to be repeatable when actually they are independent, one's own skill is believed to determine events, and that luck, the lady of supernatural powers who can direct events in your favor, can stand by your side. Bond's conclusion that the human is a poor gambler is not surprising.

Both Gabrielli and Bond talked about psychological explanations of gambling behavior, and the points that they made were the basis of much of the audience's discussion and reaction. There are four main explanations: 1. Social gambling. Some people gamble for the simple reason that they enjoy it. Instead of going to the beach, or to dinner and the theater, they go to the casino. 2. Masochism. The gambler derives pleasure from losing; he enjoys punishment. 3. Reinforcement schedule. The rewarding of a response can follow a certain number of responses irrespective of when responses occur (ratio schedules), or it can occur at certain time intervals irrespective of the number of responses (interval schedules). Gambling fulfills the definition of a reinforcement schedule called variable ratio, which has a statistical definition whereby a response is rewarded for every n occurrences on the average. A slot machine may pay after two pulls of the handle, then after 15 pulls, then after 8 pulls more, etc., with the average being a reward, say, after every 10 pulls. A variable ratio schedule produces a high rate of responding, and psychologists use it to explain the persistent responding of the inveterate gambler. Runs of non-rewarded responses do not deter him because he knows that a reward eventually will come, and this expectation, which is always fulfilled with the variable ratio schedule, maintains the gambling behavior. 4. Learning relevant information about the game. Gamblers learn adaptive behavior for the game; they get good at losing slowly, and so they have a feeling of control over the game. The player who mentally tallies the cards showing can update the probability of occurrence of a card not showing, and can do a better job of predicting the card's occurrence than someone who has not made the tally.

The last explanation is undoubtedly true, and social gambling is a credible hypothesis, but the other two explanations have some scientific distance to travel before they are acceptable. Masochism, in its most vivid form in the human, involves the seeking of physical pain and gaining pleasure from it. To use it for an explanation of gambling assumes the losses between wins to be painful. There is no evidence that this is so. An equally reasonable assumption is that losses are merely discomforting and that they are offset by the pleasureable anticipation of the next win. Pain is hardly involved.

The variable ratio schedule has the merit of animal data in support of it, but as an explanation of gambling it is an analogy with the animal data, not direct evidence. We need studies that show how human gambling behavior can be put under the control of different variable ratio schedules. Developmental studies, showing how gambling behavior can be first taught, and then maintained and manipulated in young children, with variable ratio schedules, would be instructive. Furthermore, with the event sequence in a variable ratio schedule being a probabilistic one, a close examination of the behavior could reveal the misperception of probabilistic events that underly some of the gambler's fallacies. How fallacies are acquired and controlled could be a valuable byproduct of research on reinforcement schedules and gambling behavior. (Jack A. Adams)

SPACE SCIENCES

THE DANISH SPACE RESEARCH PROGRAM

Even though Denmark is the smallest contributing member state of the European Space Agency (ESA) (1.44% of the 1977 budget), its space program is generally well organized, and the quality of its space science and technology experiments high. Denmark has no national space program as such, but participates in the ESA programs by and large through the Space Committee of the Danish Research Administration, which is an arm of the Ministry of Education. This Committee, comprised of between 10 and 15 members from industry, universities, and laboratories, meets twice a year, gives broad instructions to ESA delegates and recommends to the Ministry those space programs in which Denmark should participate and to what degree. Approximately 80% of the Danish space budget goes to support its representation in ESA for which, as with all member states, it gets an equitable return in ESA contracts. The philosophy behind supporting a space program is to raise the general level of technology in Denmark as well as to encourage scientists and university stu-

dents to carry out research in space related areas.

The three main establishments with an interest in space research are the Danish Space Research Institute (DSRI), the Electromagnetics Institute of the Technical University of Denmark, and the Ionosphere Laboratory of the Danish Meteorological Institute. The DSRI was established in 1968 as an off-shoot of a group at the Technical University interested in rocket experiment instrumentation. Their basic funding comes directly from the Ministry of Education, but they compete for projects from ESA, NASA, and other institutions funding space research projects. The staff consists of about 20 engineers and physicists and 20 support personnel. The scientific staff is involved with the design and development of hardware experiments and the analysis of subsequent data. The laboratory facilities are small but excellent, consisting of an electronics design laboratory in which electronic circuits are taken from the drawing stage to completed boards; a mechanical workshop; a clean-room assembly and test laboratory; and a small computer facility for data analysis.

The research is currently organized by project in two divisions, a Cosmic Radiation Division which is involved with the study of the chemical and isotopic composition of galactic radiation, and a Near Space Division that studies the particle and electromagnetic wave composition of the magnetosphere. The first is heavily involved in the final development and test of an experimental package to be flown on the NASA HEAO-C (High Energy Astrophysical Observatory) satellite in 1979. This package is a joint venture with France designed to analyze the energy and isotopic mass spectra of selected chemical elements contained in galactic cosmic rays. In addition to participating in the hardware part of the experiment, the DSRI will perform scientific analysis of the data. The Near Space Division is participating in an experiment onboard GEOS (the ESA geosynchronous experimental satellite) that will measure the electromagnetic wave spectrum at synchronous altitude over the range of dc to 77 kHz in the electric case and 0.2 to 10 kHz in the magnetic case. In this case DSRI, as a subcontractor to British Aerospace Company, is responsible for the measurement of the ac fields. Since the geomagnetic field lines of the geosynchronous orbit "touch down" in Scandinavia at the auroral points, DSRI plans on making ground measurements of particles and electromagnetic waves to correlate with the satellite measurements. They also have rocket and balloon programs underway to correlate with the satellite data.

While the Institute expects to be heavily involved over the next three years in analyzing HEAO-C and GEOS data, they are continuing their theoretical work directed at better understanding the geomagnetic cut-off. The approach used is to examine individual cosmic-ray particle motion in the geomagnetic field using digital computers on a step-by-step basis. DSRI is using their computer facility for these calculations with the aim of correlating them with HEAO-C data. Future programs under consideration include participation in a Canadian/Scandinavian satellite project intended to study the polar ionosphere and also in the NASA/ESA Out of Ecliptic (OOE) mission, that envisages sending two space probes to Jupiter which will return to Earth passing over the Solar North and South poles. Both experiments would give DSRI an opportunity to look at auroral behavior, an aspect of space science of interest to all of the Scandinavian countries because of their location.

The Electromagnetics Institute of the Technical University of Denmark (TUD), which was the prime instigator of DSRI, is still involved in many space science related areas including line-of-sight propagation of radio waves in the 13-15-GHz range, remote sensing, antenna pattern prediction for high frequency satellite antennas, and electromagnetic compatibility in satellite broadcasting systems. The TUD covers four main educational disciplines: Chemical, Civil, Electrical, and Mechanical Engineering. It was founded in 1829 in close collaboration with the University of Copenhagen and in 1889 acquired its own facilities which are today located on a single autonomous campus at Lyngby. The building, office, and laboratory facilities are extremely modern and well equipped. TUD has approximately 3000 students with 550 scientific staff members, 140 postgraduate students, and 600 assistants, and offers both the MS and PhD degrees.

The Danish remote sensing program, pioneered by TUD, started in 1968 with expeditions to Greenland to measure the ice thickness with airborne radio

aerosounders at 60 and 300 MHz. The completion of this program is designed to produce a complete under-ice contour map of Greenland. Another important current project at TUD is to investigate sea ice thickness and composition, a task which is complicated by the nature of its very dynamic tendencies. The completion of an airborne synthetic aperture radar system with on board data processing, to accomplish this mission is imminent. The Electromagnetics Institute is preparing to participate in the Canadian SURSAT (surveillance satellite) program, a general remote sensing satellite system, and will underfly the SEASAT (NASA sea observation satellite) with airborne radar to verify and correlate satellite data.

In the area of satellite system antenna measurements, substantial progress has been made in the theory for computation of antenna far-field patterns from measurements of the near-field pattern made on a spherical surface encompassing the antenna. A computer program with several unique features has been developed at the Institute to transform the near-field pattern to the far-field one. Both the near-field and the computed far-field are described in spherical coordinates by points spaced equidistantly in elevation and azimuthal angles. One unique feature of the program is its ability to correct for the aperture size and directivity of the probe antenna. A technical paper on this program was scheduled for presentation by its developer, Frank Jensen (formerly a member of the Institute, but now with a private firm, TICRA Aps) at the 17th International Symposium on Antennas and Propagation in Sendai, Japan, 29-31 August. As a result of initial far-field antenna studies by TUD, a joint effort between ESA and the Technical University has been instituted to build an experimental facility for near-field testing of spacecraft antennas. A report of the SNFT (spherical near-field technique) facility has been completed, and the implementation phase is underway. This phase involves developing hardware for a largely manually operated facility to verify computer calculations. The overall plan is expected to result in the establishment of an automated SNFT facility in the University's radio anechoic chamber which will be used to develop and utilize the SNFT further. It is expected that this antenna testing technique will enable measurement and computation of spacecraft antennas of up to 60 wavelengths in diameter. Extension of the computation facilities to handle up to 170 wavelengths and more appears to be feasible within a few years. Details of the study are still considered proprietary by ESA, which is partially funding the project. This situation is expected to change shortly, however, and such information should soon be available from Dr. Bent Knudsen, Director, Electromagnetics Institute.

One of the poignant but recognized shortcomings of the Danish space program is the lack of interchange between the DSRI and the universities. Although it does happen, it is unusual for a student of the TUD to conduct his research at DSRI or for a DSRI staff member to lecture at the University, but attempts are being made to improve this situation.

In the author's view, the quality of space science and the caliber of the scientists in Denmark rate extremely high, especially for a country with such a small portion of its budget dedicated to space programs. (Robert W. Rostron)

NEWS & NOTES

ONRL NEWS

During the past two months ONRL has welcomed aboard several new Liaison Scientists and Naval Applications Officers. No doubt in future issues you will be reading reports by the following:
Dr. Willard D. Bascom (Chemistry), who has arrived from the Polymer Materials Branch of the Naval Research Laboratory, Washington, DC;
Dr. Irving Kaufman (Electrical Engineering), who has joined us from the Department of Electrical Engineering, Arizona State University, Tempe, AZ;
Dr. Jeff Perkins (Materials Science/Metallurgy) from the Department of Mechanical Engineering, Naval Postgraduate School, Monterey, CA;
CDR Robert D. Matulka, USN, (Airborne Systems Officer) whose last assignment was with the Naval Electronics Systems Command, Washington, DC;
CDR John A. Holt, III, USN, (Undersea Systems Officer), who comes to us from

Headquarters Allied Commander, Northeast Mediterranean, Ankara, Turkey;

Along with the arrivals we also had departures, and we bade bon voyage to Dr. I. Melvin Bernstein (Metallurgy), who has returned to his post as Professor in the Department of Metallurgy and Materials Science, Carnegie-Mellon Univ., Pittsburgh, PA;
Dr. Nelson M. Blachman (Electronics Engineering), a former staff member (1958-60) and a recent Technical Editor of ESN, who has returned to GTE Sylvania in Mountain View, CA;
Dr. William J. Gordon (Mathematics), who has taken up a position with IBM, Yorktown Heights, NY.
On the military side, CDR Connelley D. Stevenson, USN, (Undersea Systems Officer) retired from the Navy and has entered private industry in Rockville, MD, and CDR David A. Hart, USN, (Airborne Systems Officer) has been transferred to the Naval Electronics Systems Command, Washington, DC.

We wish them all smooth sailing in the future.

FRENCH PHYSICAL SOCIETY AWARDS

The French Physical Society has announced the following as its prize-winners for 1978: The Jean Richard Physics Prize (FFr 55,000) to Michel Henon, an astrophysicist at the Nice Observatory, for his work in general and in particular for his research on strange attractors; the Jean Perrin Prize for Popularization of Science to Charles Penel, Deputy Director of the Palais de la Découverte, for his work to promote and diffuse scientific culture; the Félix Robin Prize to the Physicist Henri Benoît, Director of the Strasbourg Research Center on Macromolecules, for his work in general; the Louis Ancel Prize to two specialists in condensed physics, Xavier Duval and André Thomo, both physical-chemists at the Physical and Chemical Kinetics Center in Nantes; the Aimé Cotton Prize, for research in atomic and molecular physics, to Claude Camy-Pevretaand Jean-Marie Flaud, of the Univ. of Paris XI; the Paul Langevin Prize, for a theorist in physics, to Jean Illiopoulos, of the Ecole Normale Supérieure; The F. Joliot-Curie Prize to the nuclear physicist Jean Delorme, of the Claude Bernard Univ. in Villeurbanne; the Esclangon Prize, for research in instrumental physics, to Robert Allemand, from the Grenoble Nuclear Research Institute; and the Foucault Prize, for research in applied physics, to Andréi Stéphan Mircea, of the Electronics and Applied Physics Laboratory of Limeil-Brevannes.

PERSONAL

The Univ. of Hull has announced that the following have been appointed to Personal Chairs: Dr. J.H. Appleton in Geography and Dr. G.W. Gray in Chemistry.

Mr. H.B. Bell, Personal Professor in the Department of Metallurgy at the Univ. of Strathclyde, has been promoted to the Chair of Extraction Metallurgy.

Prof. A.R. Cusens, Head of the Civil Engineering Department, Dundee Univ., has been appointed Professor and Head of the Department of Civil Engineering at Leeds Univ.

In Britain, Sir Alec Morrison, FRS, Vice-Chancellor of the Univ. of Bristol, has been appointed new Chairman of the Advisory Board for the Research Councils. He will take up this post next year when he completes his task as Chairman of the Royal Commission on the National Health Service. He will succeed Sir Frederick Stewart, FRS.

Sir Walter Perry, the Open University's first Vice-Chancellor, is to retire on 16 June 1981, his sixtieth birthday. He was appointed in 1968, a year before the Open Univ. was established, and feels that it is time for a change of leadership. Lord Briggs (formerly Prof. Asa Briggs), the Provost of Worcester College, Oxford and former Vice-Chancellor of the Univ. of Sussex will succeed Lord Gardiner as Chancellor of the Open Univ. at the end of this year.

Mr. M.V. Posner, a member of the British Railways Board and Reader in Economics at Cambridge Univ., has been appointed Chairman of the Social Science Research Council in succession to Mr. Derek Robinson, who is retiring. He will take up his four-year appointment on 1 January 1979.

ONRL REPORTS

R-5-78 A BIOLOGICALLY ACTIVE COMBINATION OF MODULATED MAGNETIC AND MICROWAVE FIELDS: THE PRIORE MACHINE by J.B. Bateman

A generator invented by A. Priore of Bordeaux is said to produce radiation which causes certain implanted tumors to regress and cures trypanosomiasis in animals. The published biological data are briefly reviewed and thought to be persuasive. The scanty information available on the nature of the active radiation is also reviewed critically. Attention is drawn to the existence of a French patent describing the invention. A full translation of the patent document is appended. A heavily funded effort to build a machine of greatly enhanced power output is mentioned. The writer considers the project to be premature without further study of the properties of the device used to obtain the biological data already published.

R-6-78 EUROPEAN FIBRE OPTICS SURVEY—JUNE 1978 by D.A. Hart (Distribution limited to U.S. Government agencies)

This report documents the findings of a series of visits to industries working on fibre optics technology in Europe. Thirteen companies in five countries were visited. These companies' activities range from limited involvement in component development through entire fibre optics system development and research on all related technologies. A massive effort is represented by the collective activity and investment being dedicated to this emerging technology in Europe. Present and future activities of these companies deserve further evaluation from military research managers who may be planning to make use of fibre optics technology for military applications.

C-9-78 FOURTEENTH INTERNATIONAL SYMPOSIUM ON APPLIED MILITARY PSYCHOLOGY by J.A. Adams

The Fourteenth International Symposium on Applied Military Psychology was held in Florence, Italy, 15-21 April 1978, with the government of Italy as host. The theme of the conference was "Crisis of Authority in Society, and Leadership." Thirty-six representatives of 13 countries were present. This conference report reviews the 16 formal presentations that were the substance of the symposium.

C-10-78 THIRD INTERNATIONAL CONFERENCE ON RAPIDLY QUENCHED METALS by J. Perkins

The technical content of the Third International Conference on Rapidly Quenched Metals, held 3-7 July 1978 at the University of Sussex, is reviewed. Papers on techniques of rapid quenching, metallic glass formation, crystallization from the amorphous state, applications of metallic glasses, and other subjects covered at the conference are described.